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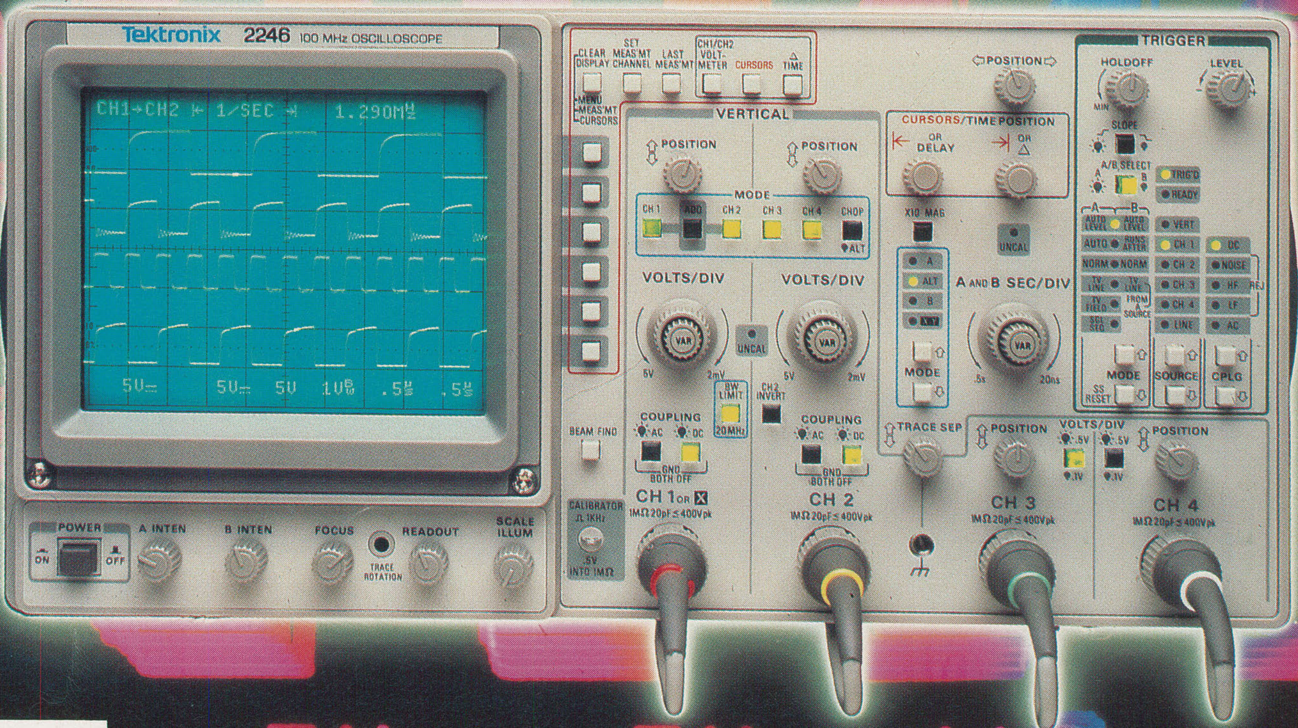

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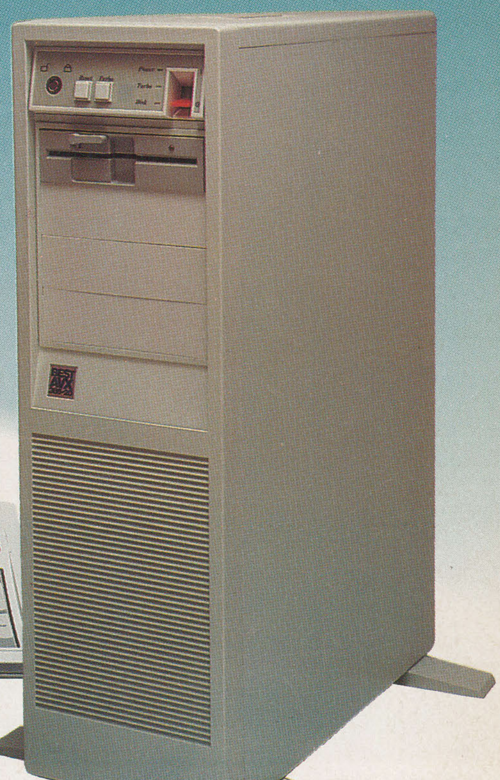

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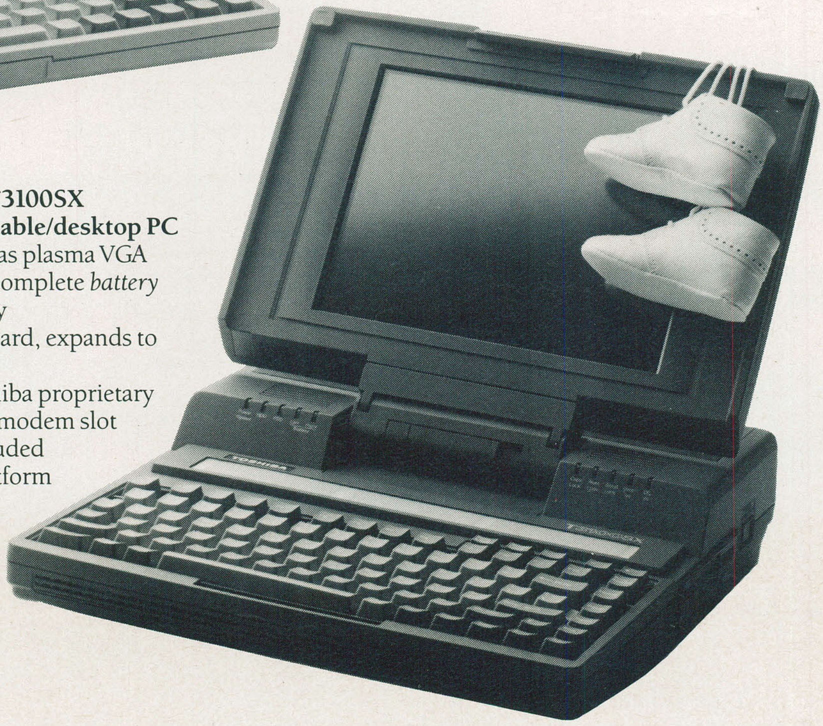

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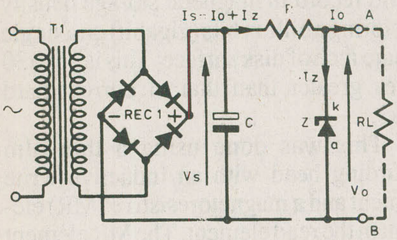
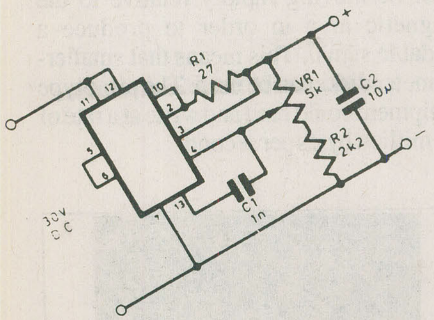
Canada's Magazine for High-Tech Discovery

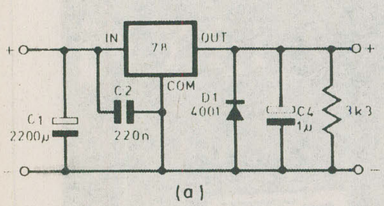
Volume 14, Number 1 January, 1990

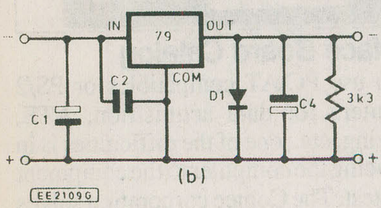


FEATURES



PROJECTS





INFORMATION

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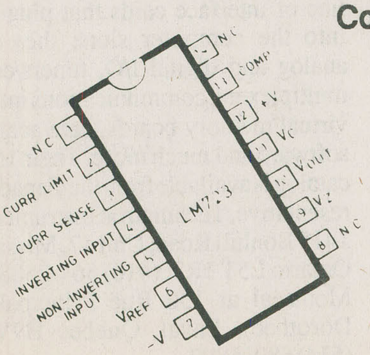

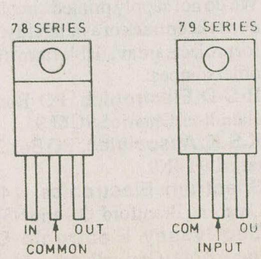

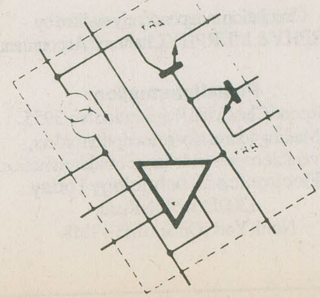

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We do not supply printed circuits or kits, and we do not keep track of availability. However, PCBs for projects are available from the following mail order sources:
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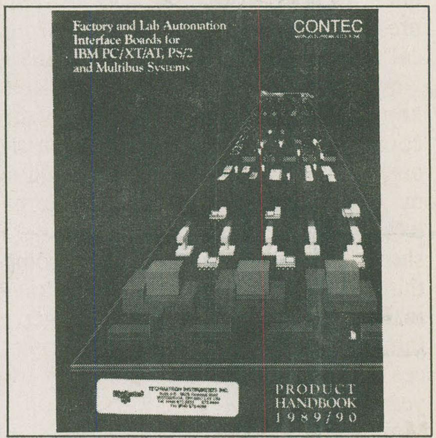
Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario N3R 7E6.
GeoDyssey Electronic Development Inc., 8744 Greenall Avenue, Burnaby, B.C., Canada V5J 3M6.

Highest Magnetic Density

Researchers at IBM in San Jose have set a world record in magnetic storage density by storing a billion bits (gigabit) on a single square inch of disk surface. This is 15 to 30 times greater than that of current hard disks.

This was done using a thin-film recording head with an inductive write element and a magnetoresistive (MR) element in the read element. The MR element has the advantage that its resistance changes in the presence of a magnetic field, even if it isn't moving; the inductive head must be moving rapidly relative to the magnetic area in order to produce a readable signal. This means that smaller-diameter disks can be used. The prototype equipment could read and write at a rate of 3.5 million bytes per second.



Interface Board Catalog

If you use PC\AT compatibles or PS/2 computers for data acquisition, ATE, analyzing, etc., one of the difficulties is in interfacing the computer to the equipment under test. The Contec corporation solves the problem economically with their huge line of interface cards that plug directly into the computer slots; they include analog and digital I/O, timers/counters, multiplexers, communications interfaces, virtual memory boards, data acquisition, software and much more. Their 154-page catalog is available from the Canadian representative, Techmatron Instruments Inc., 1415 Bonhill Road, Unit 17, Mississauga, Ontario L5T 1R2, (416) 564-2588, and in Montreal at 130 Rue Principale (Ste. Dorothee), Laval, Quebec H7W 3S6, (514) 689-5889.

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DOS-Based Scope

National Instruments announces a software package for controlling the company's first Extended Industry Standard Architecture (EISA) plug-in data acquisition board. VisionScope is a ready-to-run DOS package that creates the look and feel of a traditional scope; the on-screen front panel resembles the familiar scope panel, but adds point-and-click muse or keyboard controls. The user has instant recall of frequently used test setups, capture of waveforms for comparison or later analysis, zooms, delta cursors and more. For further information contact Allan Crawford Associates, 5835 Coopers Ave., Mississauga, Ontario L4Z 1Y2 (416) 8890-2010.

Circle No. 4 on Reader Service Card

One Man's Meat...

"And swords and guns and uniforms lay scattered on the ground." You'd think that peace bustin' out all over would be unqualified good news for everybody, but a press release from the Institute of Electrical and Electronics Engineers (IEEE) in New York indicates that they don't quite know what to make of it. They're mostly concerned with the loss of jobs in the defence industry, and they found that no major defence contractor had any alternative programs. Hey, no problem — it shouldn't be hard to come up with something for them to do: lots and lots of things in the world need fixing, from outrageous things like world hunger to mere annoyances like mufflers that fall off every two years.

Meter Source

Need DMMs, special meters, data communications testers, etc? Tradeport Electronics features TES meters, including the TES-2220 Autoranging multimeter and the TES-1310/1320 Digital Thermometer with single or dual channels and differential measurement. The K&C DS-300 data communications tester has an 8-line by 32- character readout and terminal emulation for all common protocols. Tradeport Electronics Group, 220 Wildcat Road, Downsview, Ontario M3J 2N5, (416) 736-0866, Fax 736-9102.

Circle No. 5 on Reader Service Card

Replacing Electronics

Well, not just yet, but IBM researchers in New York have reported being able to control a beam of electronics in gallium arsenide at -450°F. The beam of electrons travels only 2 microns (millionths of a metre), but since it doesn't suffer the usual collisions with molecules of the conductor, it remains at a very high speed, about 1,000,000 miles/hr. The distance may be short, but it lends itself to very high speed computer switching, and if severe hurdles can be overcome, the technique might be in use in 21st century computers.

After all, Spock did tell Captain Kirk that an old spaceship used "an obsolete method called electronics". You never know.

Rent Increase

Electro Rent has announced that with the closing of the Instrument Rentals Canadian operation, it will offer to all previous customers of Instrument Rentals the same service that was provided in the rental, sale and lease of electronic equipment.

Electro Rent has also added new products to their inventory, including Sun Microsystems for rent and NEC Data for sale. You can get further information by calling 1-800-268-0437 in Ontario and Quebec, 1-800-268-0216 national.

Full-function DMM

Prema Instruments have introduced their new Model 6001 System DMM for benchtop measurement systems. Accuracy is a remarkable 0.004%. In addition to the standard voltage, current and resistance ranges, the Prema 6001 can measure temperature from - 200° to +850°C. The display is a 6 1/2 digit LED with autoranging. Duncan Instruments, 121 Milvan Drive, Toronto, Ontario M9L 1Z8, (416) 742-4448.

Circle No. 11 on Reader Service Card

Continued on page 41

PROJECT

Build a Seismograph, Part 2

Watch for earthquakes and nuclear tests around the world. This month: the mechanical construction.

TONY HOPWOOD AND ANDY FLIND

The mechanical construction of the seismometer is straightforward, and requires no precision engineering. Most of the materials can be obtained as scrap and recycled as befits an earth sciences project. The one critical operating parameter is friction, so the sensing beam must pivot on a smooth surface like a small ball bearing. I used the flywheel spindle of a defunct cassette player because it had a hardened and ground spherical bearing surface. This sits in a conical counterbore on a quarter inch bolt head screwed into the back post. A ballpoint pen end will work just as well.

Size of the instrument is a matter of choice. I built a rather large unit because I had room for it. In urban areas, an instrument with a longer period than 6 seconds will tune out most of the traffic vibration, and the size can be cut by increasing the mass and keeping the beam angle to a minimum. This means better quality mechanical engineering.

I used a 48 inch long pendulum beam of 20mm square section aluminum tube. The beam must be light and rigid, because it will be loaded with extra weight to tune it. (Fig. 1).

The base is a 60 inch length of 5 inch by 3 inch timber. At the pivot end it is screwed onto a transverse 24-inch piece of 1.5 inch square steel box section fitted with 3/8 inch levelling screws. A piece of angle with a single levelling screw is fitted to the sensing end.

The pendulum beam hangs from a 36 inch vertical iron post coach bolted to the wooden base and thus kept insulated from the earth. The unit should work just as well if the post is fixed to a SOLID ground floor or the beam is hung from a basement wall. Ordinary cavity walls are not rigid enough, and may prove too sensitive to people, traffic and temperature changes.

At the top of the post is an adjustable screw eyebolt vertically above the beam pivot support bolt (see photo).

The beam is suspended by a thin stranded alloy wire (not soft copper), adjusted to hold it parallel to the base and some 5 inches above it. The suspension point is 15 inches from the outermost end of the beam to allow space for weights and reduce the side thrust on the pivot.

Protection

The moving beam should be protected from draughts with a light removable cover, which can be made of polystyrene water tank insulation sheet, hardboard or chipboard, and the unit should be set up on a solid ground floor away from people and vehicles.

It is mechanically set up first. The oscillation period depends on the angle the beam makes with the horizontal and its ef-

fective mass. To give an accurate seismic response, mechanical damping must be added. Liquid damping is simplest using an adjustable aluminum vane (100 X 50mm) under the beam which dips into a container of paraffin or light oil, or even water if there is no risk of freezing.

If the instrument is installed in an outbuilding with wide temperature swings, paraffin will give the most constant damping, but will need a larger vane than oil.

Loading

The beam is loaded with up to 5kg of extra weight near the end. I used short lengths of scrap iron pipe slipped on to the beam.

When the beam is loaded, the pivot end of the instrument is jacked up about 10mm to turn it into a sensitive long period pendulum. This is a matter of trial and error. The important thing is to establish a stable mechanical zero and period greater than 7 seconds.

Once a period of 7-10 seconds is achieved, the damping is set by adding liquid to the vane bath — a small plastic food container is ideal for this — until the pendulum comes to rest after one and a half to two swings.

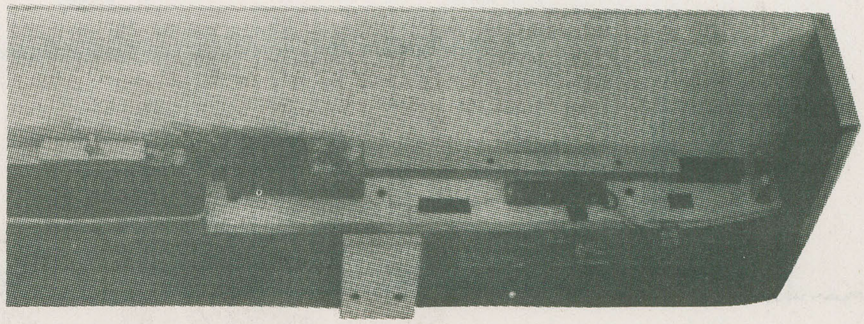
Sensing

The sensing coils and electronics are now fitted. Care should be taken to arrange a non-metallic mount for the sensing coils — I used a plastic pipe clip for the static coil and a piece of square section insulating plastic bar clearance drilled for the moving coil, and pressed into the end of the sensing beam. The coil must be a LOOSE fit in the hole, to avoid damaging the windings; it can be secured with wax or similar.

The lead from the moving coil needs to be very flexible and is fed inside the beam to a hole close to the pivot. A loop is then taped to the support column, and the lead taken to the detector board pins. The detector board is mounted on the wooden base.

After assembly, the instrument may take a few days to settle down, but thanks to the generous clearances in the pick off system, no great precision is needed, and deviation from zero can be corrected by the jacking screws.

The beam and support pillar should be bonded to the negative rail of the electronics. If the instrument is to be used at some distance from the monitor point, it must only be earthed there — any earth



General arrangement of the beam, sensing coils, damping vane and detector board. Part of the draft protection can be seen.

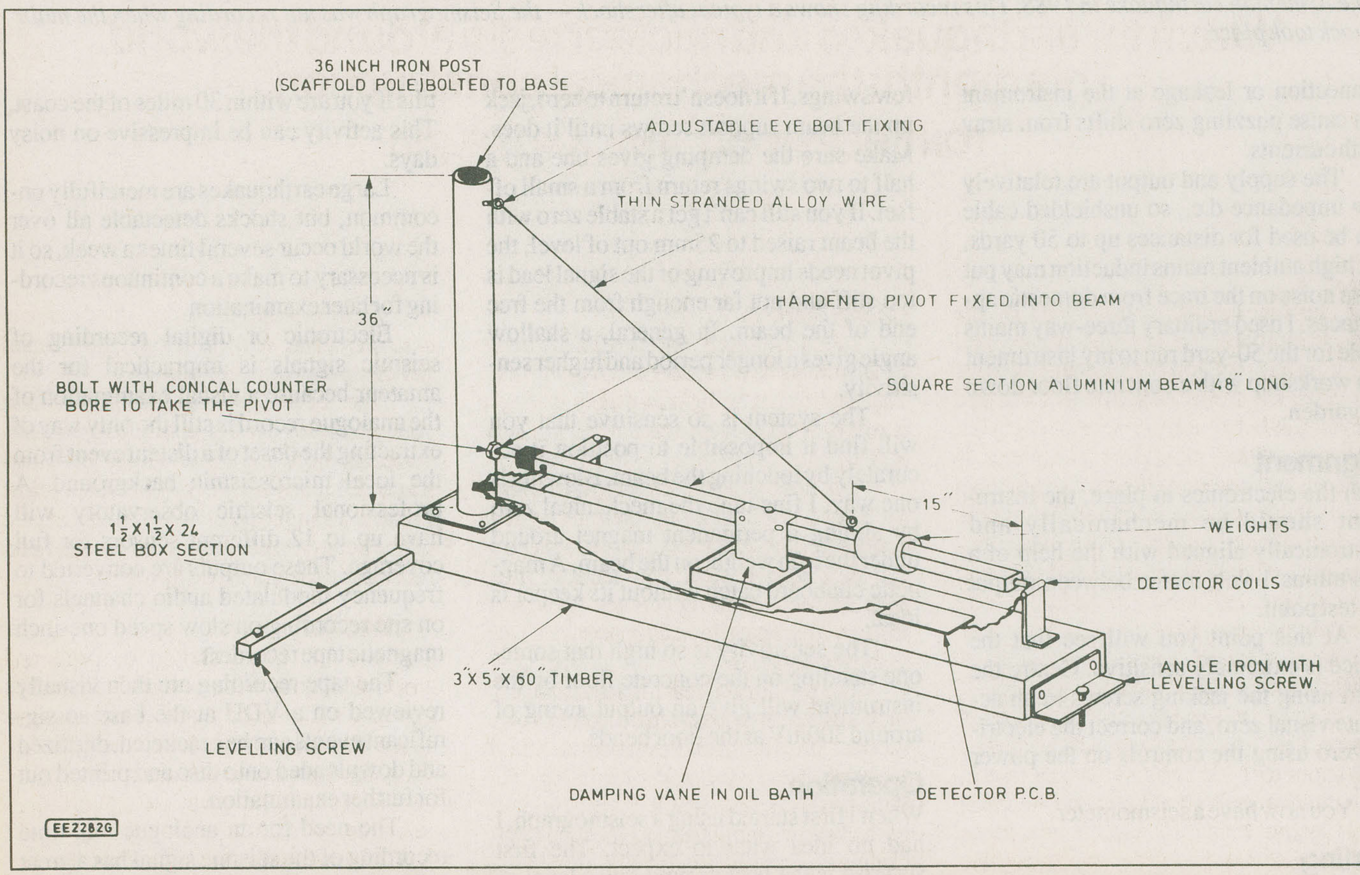
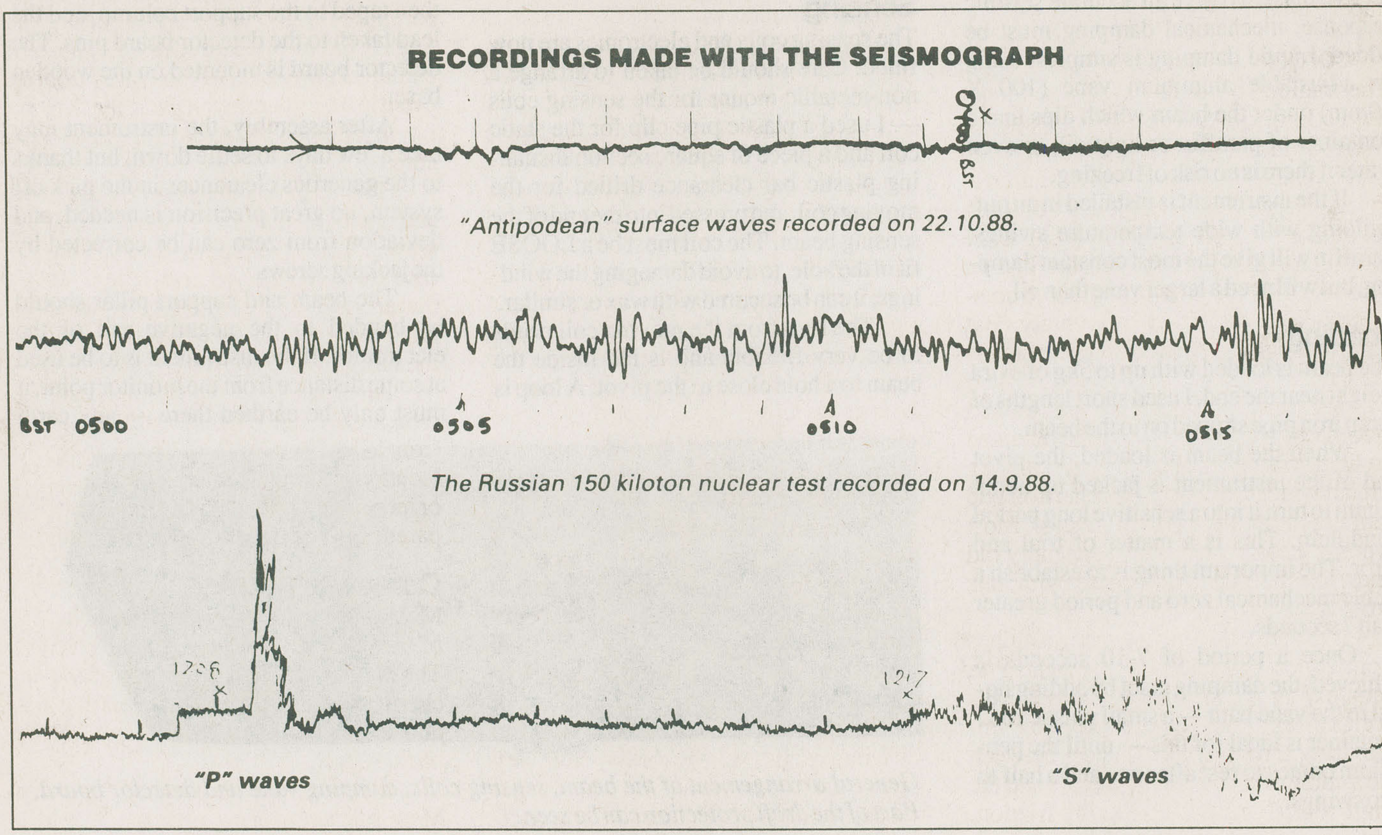


Fig. 1. Construction of the Seismograph.



The Armenian earthquake in 1988. This recording shows a typical aftershock — the Seismograph was not recording when the main shock took place.

connection or leakage at the instrument can cause puzzling zero shifts from stray earth currents.

The supply and output are relatively low impedance d.c., so unshielded cable can be used for distances up to 50 yards, but high ambient mains induction may put extra noise on the trace from domestic appliances. I used ordinary three-way mains cable for the 50-yard run to my instrument in a workshop with a concrete floor down the garden.

Alignment

With the electronics in place, the instrument should be mechanically and electronically aligned with the help of a plus/minus 1 volt meter between output and test point.

At this point you will see that the device is extremely sensitive. Centre the beam using the jacking screws to an accurate visual zero, and correct the electrical zero using the controls on the power unit.

You now have a seismometer

Testing

Test for stable zero by blowing the beam gently to one side; it should settle after a few swings. If it doesn't return to zero, jack up the beam support screws until it does. Make sure the damping gives one and a half to two swings return from a small offset. If you still can't get a stable zero with the beam raised to 25mm out of level, the pivot needs improving or the signal lead is too stiff and not far enough from the free end of the beam. In general, a shallow angle gives a longer period and higher sensitivity.

The system is so sensitive that you will find it impossible to position it accurately by touching the beam. Blowing is one way. I fine tune the mechanical zero by sliding a permanent magnet around under the iron weight on the beam. A magnetic cupboard catch without its keeper is ideal.

The sensitivity is so high that someone standing on the concrete floor by the instrument will give an output swing of around 300mV as the floor bends.

Operation

When I first started using a seismograph, I had no idea what to expect. The first surprise is the background noise level or microseisms caused by low pressure weather systems, traffic, trains and tidal tilts if you are within 30 miles of the coast. This activity can be impressive on noisy days.

Large earthquakes are mercifully uncommon, but shocks detectable all over the world occur several times a week, so it is necessary to make a continuous recording for later examination.

Electronic or digital recording of seismic signals is impractical for the amateur because a visual examination of the analogue record is still the only way of extracting the onset of a distant event from the local microseismic background. A professional seismic observatory will have up to 12 different sensors for full coverage. These outputs are converted to frequency modulated audio channels for on site recording on slow speed one-inch magnetic tape recorders.

The tape recording are then visually reviewed on a VDU at the base so significant events can be bracketed, digitized and downloaded onto disc and printed out for further examination.

The need for an analogue real time recording of the seismic signal has a great influence on the choice of chart recorder. For adequate detail, a minimum speed of 15mm per minute is required. This trans-

lates to about one metre per hour — so paper economy is important.

Recorder

The traditional mechanical seismograph used a large drum covered with paper or smoked glass. The drum was arranged to move axially about 6mm per revolution to give a very long spiral trace for each recording. These days, a spiral trace electronic seismograph recorder can be built using standard electronic servo components and mechanical ingenuity. But this is perhaps beyond the scope of many readers.

For those who don't want to build a recorder, paper economy can be obtained on linear trace machines, by constructing a hand winder to rewind the chartroll and running multiple parallel traces. Most types of chart recorder — especially old ones can be adapted for use with this project.

It is possible to convert machines from expensive sprocket drive paper to narrower or cut down plain paper rolls (Telex, Fax, calculator or till), by improvising a rubber pinch wheel between the middle of one of the guide bars and the chart roll to drive the paper by friction. Precision rubber rollers can be made from ordinary black rubber grommets pressed onto a piece of brass or plastic tube and ground to fit the clearance between guide bars and chart drive roll. The roller is ground to size by fitting it on a screwdriver or suitable bearing and holding it at an angle against a bench grindstone wheel so it spins rapidly as the rubber is evenly ground away. Wear gloves and eye protection

Accurate timing is important for seismographic observation, so timing marks should be added on the trace either by hand later or by means of a generator. The simplest timing mark generator is a mains synchronous motor operating a microswitch every minute. If a changeover microswitch is used, a small capacitor can be charge to a few volts d.c. through a resistor and discharged to make a pip on the trace every minute. Some recorders have internal timing mark generators, and these can be triggered by a timer.

It is essential that the marker is superimposed on the trace, not on the side of the chart if spiral or multiple track recordings are made. New synchronous 1 r.p.m. motors are expensive, so an attractive option is the defrost cycle controller from a defunct microwave oven. These are usually small cased synchronous timers with a 30 second on and 30 second off mains switched output which can be used to pulse a relay to generate isolated low voltage timing marks. If hour marks can also be added, they can be distinguished by switching a small d.c. offset on to the trace for a few seconds or lifting the pen to leave a short gap if the recorder has a remote pen lift facility.

Recorder Supplies

There are a number of possible sources for used chart recorders of various types. These were often used in industrial boiler houses (thermocouple recorders) and of course in school or collage labs or as electrocardiographs in hospitals etc. (although the paper speed on the latter would need to be reduced).

Various circular paper type recorders could also be used to give a reasonable recording for the Seismograph. It should not be too difficult for most readers to unearth a suitable instrument in an electrical junk shop or through local industry or educational establishments, etc. Most of the original users have now changed to different methods of recording and very often chart recorders are no longer needed; while many of them look distinctly old fashioned they are usually excellent examples of precision engineering and are rarely worn out or broken.

Observing

Earthquakes are truly natural random events, and cannot be predicted, so the only way to catch a big one is to keep the equipment running continuously. This means logging the start and finish of each trace carefully so that the arrival time of any event can be determined accurately from the minute markers.

EArthquakes are caused by stress induced fracture and movement of the earth's crust and the semi-liquid mantle under it, and can occur a depths down to 500km, although most occur in the upper 50km of the solid crust.

The energy released is transmitted radially from the fracture, and has most effect on the surface immediately above. A shallow earthquake will create a comparatively small area of devastation whereas a powerful deep event will lay waste large areas.

The earth appears to comprise a heavy molten nickel-iron core about 5000km in diameter, overlaid with a lower density viscous and semi-solid mantle which supports and floats the solid surface crust and continental plates.

The speed of propagation of an earthquake wave varies with density. The liquid care of the earth does not transmit earthquake waves at all, so waves from an event in the eastern hemisphere reach us via the mantle and crust, passing around the core.

The different densities of the crust and upper mantle modify the speed of the waves. The deepest waves skirting the core travel at 8km/second. These waves that are ducted in the interface between the crust and mantle make 5km/second, and the surface waves make 4km/second.

An analysis of the difference in arrival times and character of the waves from a specific event will give a clue to the location of the epicenter, and when three or more synchronized recordings are compared, the exact location may calculated.

Computerizing

Mention was earlier made of the difficulty of computerizing seismographic records. The biggest problem is distinguishing the characteristic small early signals of a distant event from the local microseismic background.

It is largely a question of frequency. Most microseismic waves are of 3 to 6 second period, whereas the first waves from an event less that 5000 miles away are of 0.5 to 2 second period, arriving through the mantle at 8km/second. They are known as P (primary) waves and represent the actual sharp impulse accompanying the energy release at the epicenter. There are no P waves from events sufficiently distant for direct propagation to be blocked by the core.

Next to arrive are the first S (secondary) waves. These travel at 5km/second in the discontinuity between the mantle and crust, and have world wide range. Last to arrive are the slow and dramatic surface waves, with periods from 8 seconds upwards, travelling at 4km/second.

Earthquakes from the activity zones around the Mediterranean and into Russia will show all three wave types and the signal from a large event should stand out clearly enough to allow a rough calculation of its probable distance from the differences in arrival times, before it gets on the news. The signals are normally direct primary waves with no secondary or persistent surface wavetrains for such minor events.

The instrument is also sensitive enough for nuclear test watching. The recording shown was made from a well-publicized 150-kiloton Russian underground test ■

Biofeedback Monitor

Investigate your brain's Alpha, Beta and Theta waves or just learn about instrumentation amps.

ANDY FLIND

A biofeedback system is normally used to make some normally imperceptible body function apparent to its user, often so that it can be strengthened or suppressed. The GSR (Galvanic Skin Response) monitor, which measures skin conductivity, is quite well-known. Skin surface resistance rises during relaxation, so someone who learns to increase skin resistance is in fact reducing stress.

Similarly, migraine sufferers have been taught to increase the temperature of their palms, as resulting changes in blood flow can apparently alleviate the headache. The ultimate objective for most amateur enthusiasts, however, is the construction of an EEG (for Electro-EncephaloGraph) brain-wave monitor.

EEG

The study of EEG patterns is a relatively new science. The presence of various electrical signals within the brain was first discovered in 1924 by a German scientist, Hans Berger, now generally regarded as the father of the art. Berger discovered Alpha and Beta waves with the aid of electrodes placed on the head of his son, Klaus.

Use of this knowledge was limited for many years simply to clinical diagnosis. In 1958, however, an American psychologist, Joe Kamiya, began experiments to discover whether subjects connected to an EEG machine could learn to increase production of various brain signals, especially alpha, and so the use of the EEG as a true biofeedback tool began.

In American simple, inexpensive EEG training machines were promoted as a way to instant Nirvana. Sadly, it seems they cannot achieve this for their users, but there is little doubt that Alpha training through biofeedback can assist the attainment of deep relaxation. This is valuable by itself in these stressful times, and for some it may prove a springboard into deeper meditation and spiritual progress.

Brain Activity

The brain produces various frequencies of electrical activity, most of which have been classified and named by researchers. The best known is the Alpha rhythm, about 7 to 14Hz, normally produced when the subject is awake but relaxed with eyes closed. Below this are Delta, 4Hz or less, found in sleep and in babies up to about a year old, and Theta, 4 to 7Hz.

Theta is attracting some attention, as training in it has enhanced visualization and creative abilities for some subjects. It has also been detected in some Zen masters during deepest meditation. Beta, from 14Hz upwards and usually strongest around 20Hz, is indicative of normal conscious activity. You will be producing Beta right now as you read this article.

By means of electrodes on the scalp, all these electrical signals may be detected, and displayed to the user. The only difficulty is that they are of very low voltage, typically 5 to 20 microvolts, and most users will be trying to detect them in the presence of several volts of induced 60Hz AC powerline hum.

Electronics

Until recently the electronics design was difficult, as the amplifier required a high input impedance coupled with a very low noise figure. Noise is a problem at low frequencies. Below the audio spectrum the noise generated by most semiconductors increases dramatically and op amps such as the 741, and many discrete transistors, are quite useless for the task.

One wonders how Berger coped all those years ago. Apparently he used a type of galvanometer, without benefit of amplification at all. Recently, however, the appearance of specialized low- noise op amps such as the OP-07 has made it possible to produce a simple and effective EEG monitor design for home construction.

Instrumentation Amplifier

A block diagram of the Monitor is shown in Fig. 1. The first stage is an instrumentation amplifier with a voltage gain of a thousand and a very high rejection of unwanted common-mode signals such as hum. This is followed by a notch filter to remove remaining traces of 60Hz noise, and an opto-isolator. This provides a safety if the project is coupled to mains-driven equipment such as computers or amplifiers. **With electrodes sited on the user's head safety is obviously of paramount importance.** At the same time, the isolation prevents possible entry of hum through the output. This part of the circuit is assembled

on a separate PCB and carefully shielded in the finished assembly.

With the minute EEG signals now raised to useable levels and stripped of mains hum, the remaining circuitry, on a second PCB is concerned with processing and output. Three filters extract Beta, Alpha and Theta signals, which are available simultaneously. They could be interfaced to a computer for graphical screen presentation, though there are obviously many interesting possibilities. A switch selects one of them to control a VCO, for an audio output on headphones. The VCO is driven either directly or through an integration circuit that gives an output corresponding to average level. Users will quickly establish their own preference from these two outputs.

For readers not familiar with the instrumentation amplifier used for the input, a simplified diagram appears in Fig. 2. It consists of three op amps. A voltage common to both inputs will appear, unamplified, at the outputs of both A1 and A2. A voltage applied to one input appears, with a gain of (Ra+Rb)/Ra, at the output of the appropriate amp. However, the current drawn through Ra will cause an almost equal but opposite output to appear at the output of the other amp.

These signals are combined in A3, a unity-gain differential amplifier circuit. The output from this is the difference between its inputs, voltages common to both being rejected. This configuration provides differential amplification, very high rejection of common-mode signals, high input impedance (since both signals go to op amp non-inverting inputs), and a potentially high gain of, approximately, (Ra+2Rb)/Ra. The circuit is often seen in industrial applications such as electrometer amplifiers. In this project the use of OP-07 amplifiers gives the additional advantage of very low noise.

Circuit — Front End

The full circuit for the front-end board is shown in Fig. 3. The instrumentation amplifier consists of IC1, IC2 and IC3. This is similar to Fig. 2, but the inputs are AC-coupled through C1 and C2 with extra protection provided by R1 and R2. High frequency rolloff is introduced by C3 to C6 to reduce gain at unwanted frequencies. R3 and R4 provide input bias, VR1 allowing adjustment to compensate for op amp offset voltages. VR2 trims for maximum common-mode rejection.

Remaining traces of 60Hz hum are then removed by the filter constructed with dual op amp IC4. This is a modified twin- T notch filter, with active feedback to the common point to sharpen the notch. Clamp diodes D1 and D2 prevent overload of the output stage IC5, an op amp which drives opto-isolator IC6. To avoid overloading the auxiliary negative supply this stage draws all its power from the positive rail.

A split supply of plus and minus 5 volts is provided for this circuit. In order to avoid a multiplicity of batteries, the output of a single 9-volt is first reduced to 5 volts by regulator IC7, then the negative supply is generated by IC8, an ICL7660 negative converter chip.

Circuit — Signal Processing

The second, signal processing part of the circuit is shown in Fig. 4. The input is developed across R1, a 470 ohm emitter load for the opto-isolator transistor. The isolator specified has a transfer ratio of about 100 percent, so in this circuit the output across R1 will about equal the input. The raw signal appears at a socket, for connection to other equipment if required. VR1 controls overall gain and is followed by buffer IC1a, one of four amplifiers in a TL064 IC The other three form two-pole bandpass filters, with Q factors of about 6.5, and center frequencies of 19.9, 9.8 and 5.4Hz for a selection of Beta, Alpha and Theta respectively.

Although EEG circuits often use a single filter with switchable frequency, there is little extra complication in providing three separate filters. The outputs are available simultaneously for recording and experiments, and switch connections are simplified. If the filter capacitor values are reasonably small some of the associated resistors will have high values, so the TL064 with FET inputs was picked for the amplifiers.

Outputs

A project intended for relaxation training should not sound harsh to the ear. The output from this circuit is a low hum, with pitch varied by the input signal. This is produced by the VCO IC3, a CMOS 4046B phase-locked loop. As the VCO output is a squarewave, the harsher components are filtered out by R23, R24 and C13, C14 before it goes to output amplifier IC4. This is a 741 op amp, which is quite capable of driving headphones at a reasonable level, especially the miniature type intended for use with personal stereos.

The filter outputs can drive the VCO either directly, or through the average level circuit around IC2, giving an output pitch that rises with overall input

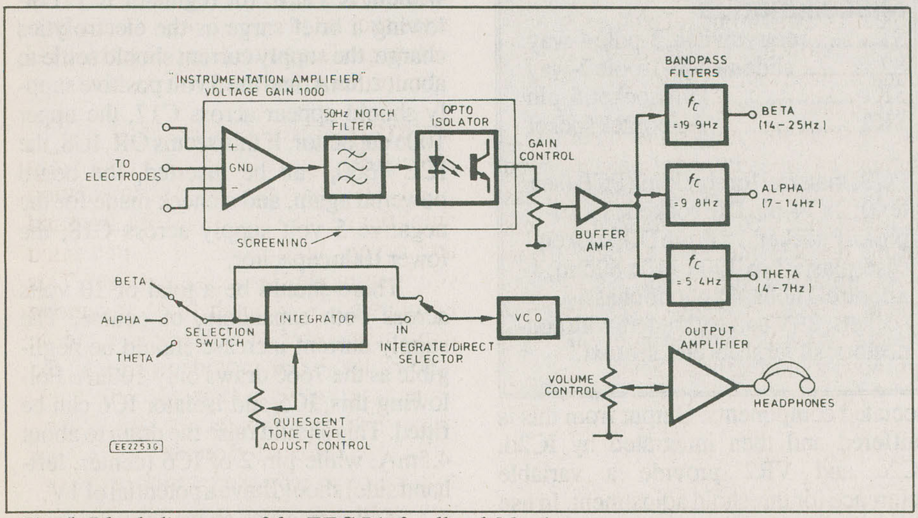


Fig. 1. Block diagram of the EEG Biofeedback Monitor.

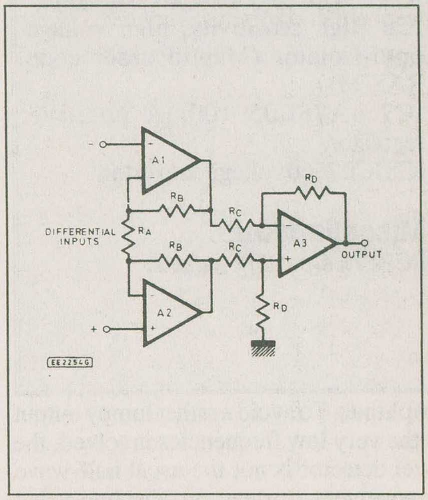


Fig. 2. Simplified diagram of an instrumentation amplifier.

Parts Lists

Front-End P.C.B.

Resistors

R1,2,20,25 .... 10k
R3,4,23 .... 1M
R5,6,10,11,13,22 .... 100k
R7 .... 1k
R8,9 .... 560K
R12 .... 47k
R14,16 .... 3M9
R15,17 .... 150k
R18 .... 120k
R19 .... 180k
R21 .... 22k
R24 .... 39k
R26 470
All metal film, 0.5W 1%

Potentiometers

VR1 100 min. hor. trim
VR2 100k min. hor. trim

Capacitors

C1,C2,C11 .... 1u polyester
C3,C4 .... 1n polystyrene
C5,C6 .... 2n2 polystyrene
C7 to C10 .... 22n 1% polystyrene
C12 .... 1n polystyrene
C13 .... 1000u 10V
C14,C15 .... 100n polyester
C16 .... 10u 25V
C17,C18 .... 100u 10V

Semiconductors

D1,D2 .... 1N4148 silicon diode
IC1 to IC3 .... OP-07C opamp
IC4 .... LM358 dual opamp
IC5 .... TLC251 LIN-CMOS opamp.
IC6 High sensitivity, high voltage opto-isolator (Maplin order code RA57M).
IC7 uA78L05 100mA positive regulator.
IC8 ICL7660 voltage convertor.

Miscellaneous

PCB; 7 x 8-pin DIP sockets.

Processor P.C.B., Case and Controls

Resistors

R1 470
R2,6,25,26 .... 1M
R3,4,14,18,23 .... 10k
R5 .... 5k6
R7 .... 12k
R8 .... 2M2
R9,12,13 .... 22k
R10 .... 3M9
R11,17,20,21,24,28 .... 100k
R15,16,22 .... 47k
R19 .... 150k
R27 .... 4k7
R29 100
All metal film, 0.5W 1%

Potentiometers

VR1,VR3 .... 10k log.
VR2 .... 10k lin.

Capacitors

C1,10,13 .... 1u polyester
C2-7,11,14,15,20,21 100n polyester
C8,12 .... 10u 25V
C9,16 .... 1u 63V
C17 .... 1n ceramic plate
C18,19 .... 100u 10V
C22 .... 470u 10V

Semiconductors

D1,D2 .... 1N4148 silicon diode
IC1 ..... TL064C quad J-FET op amp.
IC2 .... LM324 quad op amp.
IC3 .... 4046BE CMOS PLL
IC4 .... uA741 op amp.
IC5 uA78L05 5V 100mA positive regulator

Miscellaneous

S1 .... rotary switch, 3-pole 4-way
S2 .... slide switch, 1-pole 2-way
SK1 .... DIN socket, 5-pin
SK2 .... stereo jack socket

PCB; material for shielding PCB (see text); 2 x 14-pin DIP sockets; 1 x 16-pin DIP socket; 1 x 8-pin DIP socket; case, plastic box 190 x 110 x 60mm; 4 x control knobs; 4 x phono chassis sockets; 2 9V battery holders with connectors; silver sheet etc., see text.

amplitude. To avoid a rather lumpy output at the very low frequencies involved, the level detector is not the usual half-wave arrangement. Instead an absolute-value circuit is used, consisting of IC2a and associated components. Output from this is buffered and then integrated by IC2d. IC2c and VR2 provide a variable reference for threshold adjustment. In use it sets a level which the signal must exceed before the output pitch starts to rise.

This part of the circuit has its own power supply, both for safety isolation and to prevent the possibility of feedback through the power rails. With the exception of IC2 and IC4, everything operates from the 5-volt regulator IC5.

Construction — Front-End, PCB

Construction should commence with the assembly of the front-end PCB. The component layout for this is shown in Fig. 5. Both PCBs are lengthened in order to fit into the moulded slots of the specified plastic case. For different arrangements they could be trimmed short, but this should only be altered by constructors who are confident that they understand the shielding requirements.

For ease of construction, the routine of fitting the components in order of physical height should be followed. There are two links on this board. Sockets are recommended for all chips except 7, to avoid undue handling of the devices themselves and to assist testing and adjustment. Note that ICs 5 and 8 are CMOS devices so the usual precautions should be observed.

The resistors should all be one percent metal film type; these are now standard from most suppliers. Other types may result in impaired noise or hum rejection performance. The four 22n capacitors in the hum filter, C7 to C10, are 1% tolerance types instead of the usual 5%. Although opto-isolator IC6 is a 6- pin device and 8-pin socket is used as 6-pins are rare. IC6 is fitted at the top of this socket.

Front-End Checking

The front end PCB can now be checked and adjusted. It should first be powered without ICs save for regulator IC7. Following a brief surge as the electrolytics charge, the supply current should settle to about 2.5mA. and the 5 volt positive supply should appear across C17, the upper 100u capacitor. If this seems OK, IC8, the ICL 7660, can be inserted, the board powered again, and a check made for the negative 5 volt supply across C18, the lower 100u capacitor.

There should be a total of 10 volts across both capacitors, of course. The supply current increase should be negligible as the 7660 draws only 100uA. Following this, IC5 and isolator IC6 can be fitted. This should raise the drain to about 4.5mA, while pin 2 of IC6 (center, left-hand side) should have a potential of 1V.

If all seems well so far, the two inputs at the left-hand side of the board should be

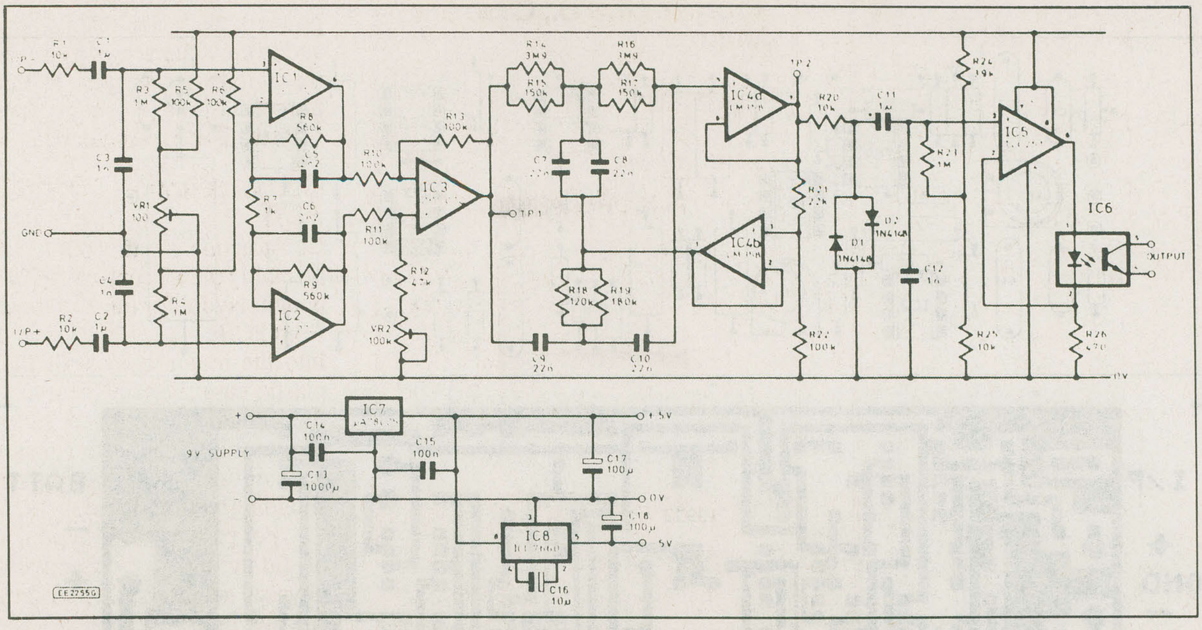
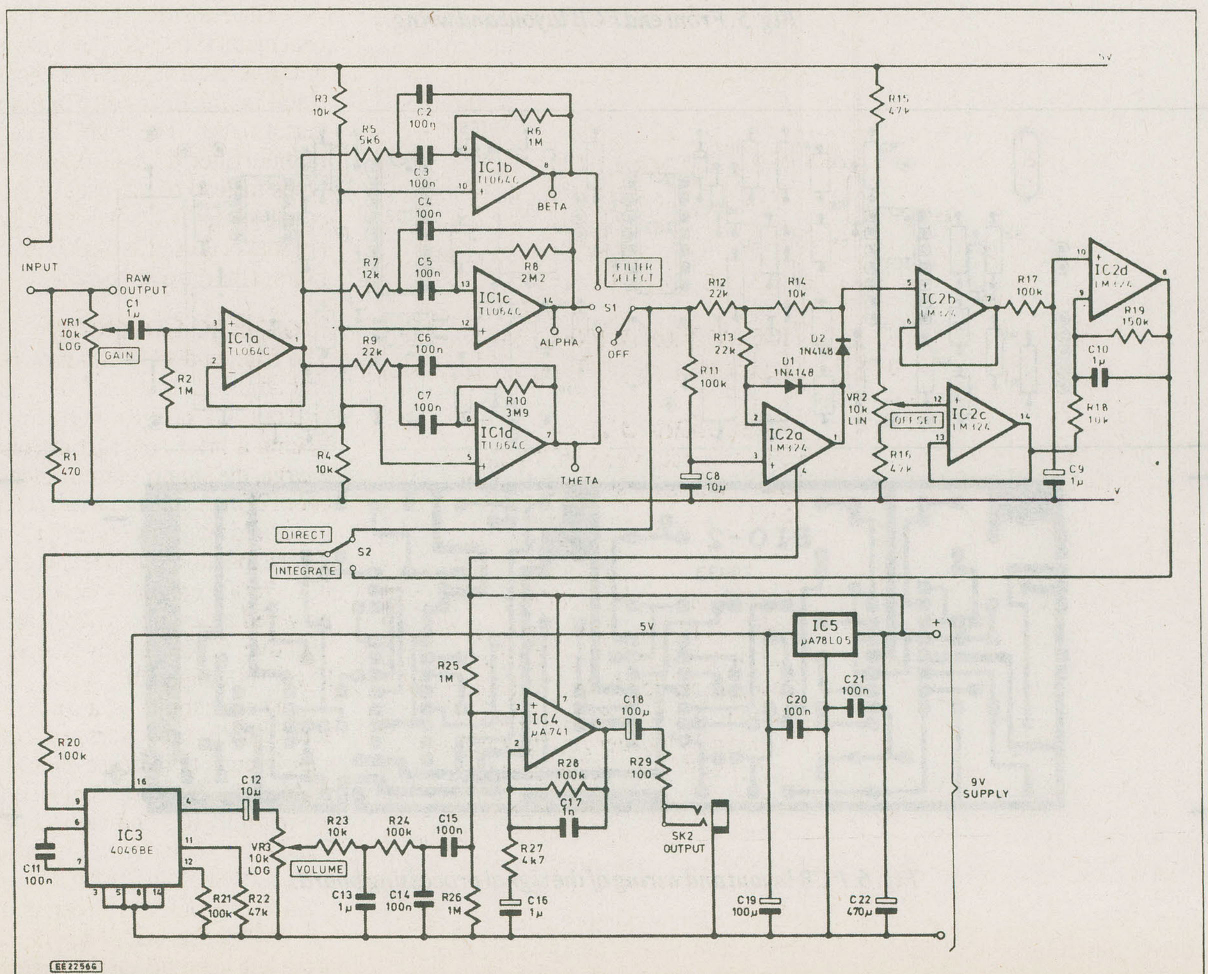


Fig.3. Circuit diagram of the "front end" of the EEG Monitor.

Fig.4 Circuit diagram of the signal processing section of the Monitor.



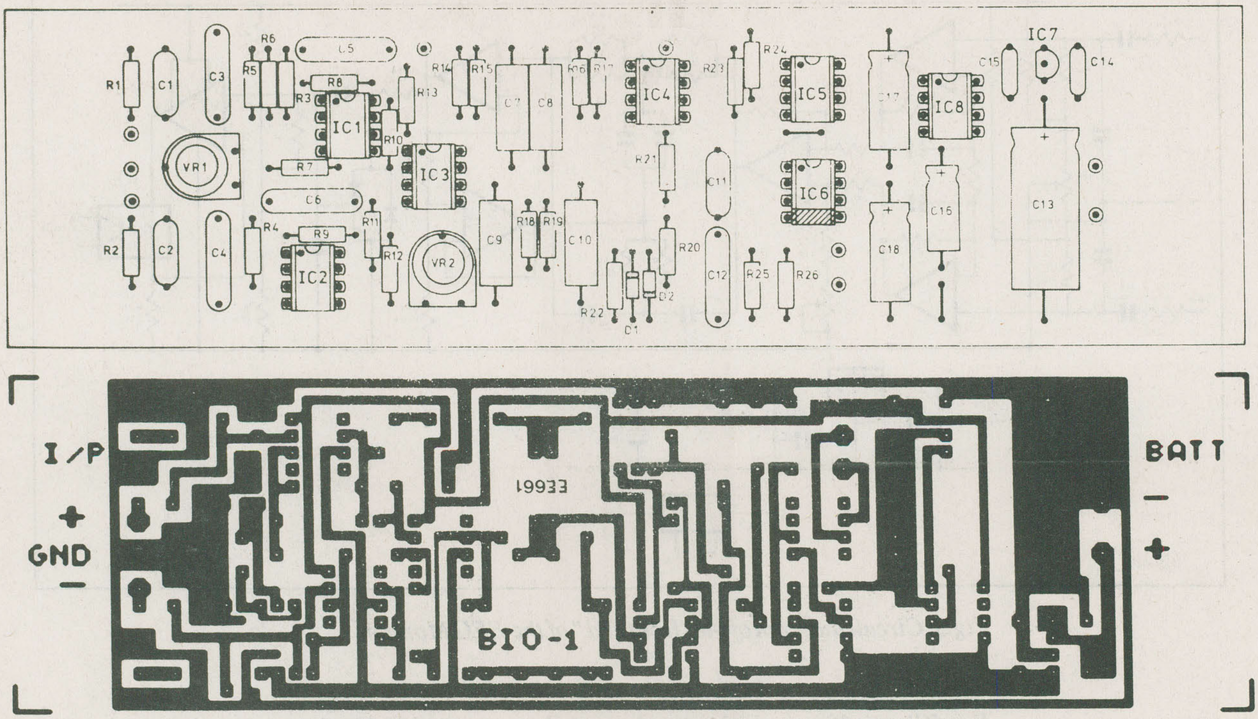


Fig.5. Front end PCB layout and wring.

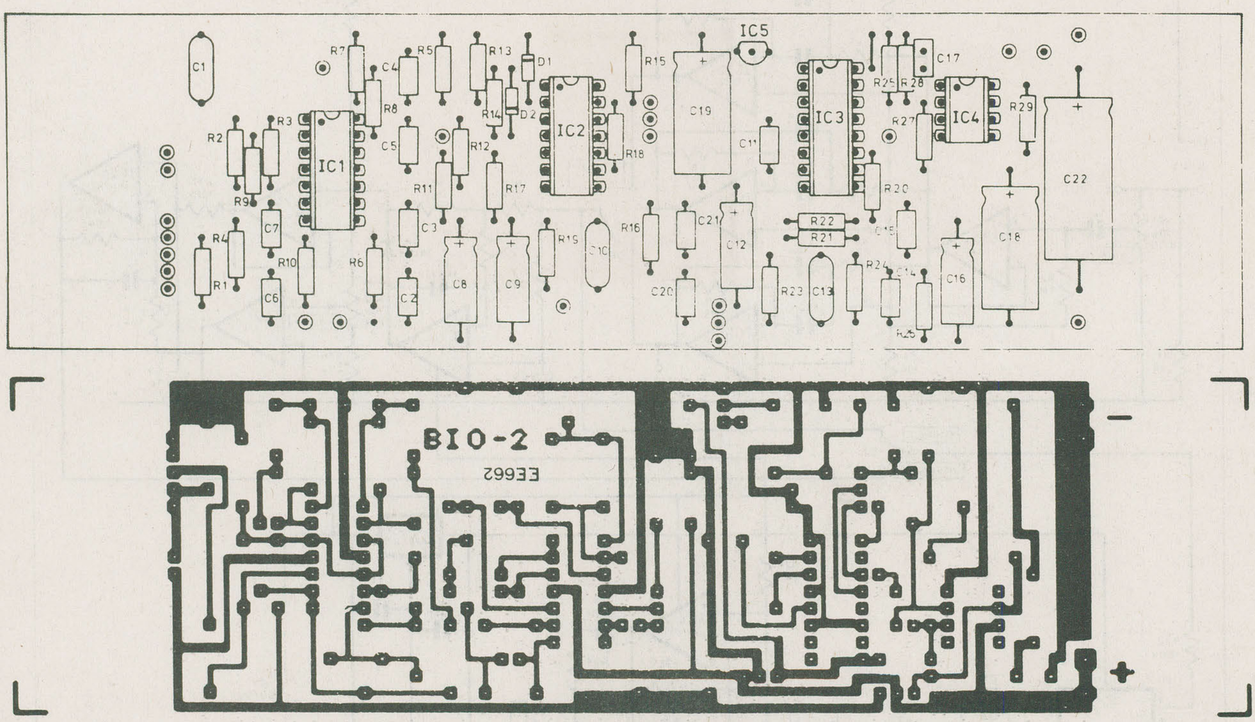


Fig.6. PCB layout and wiring of the signal processing board.

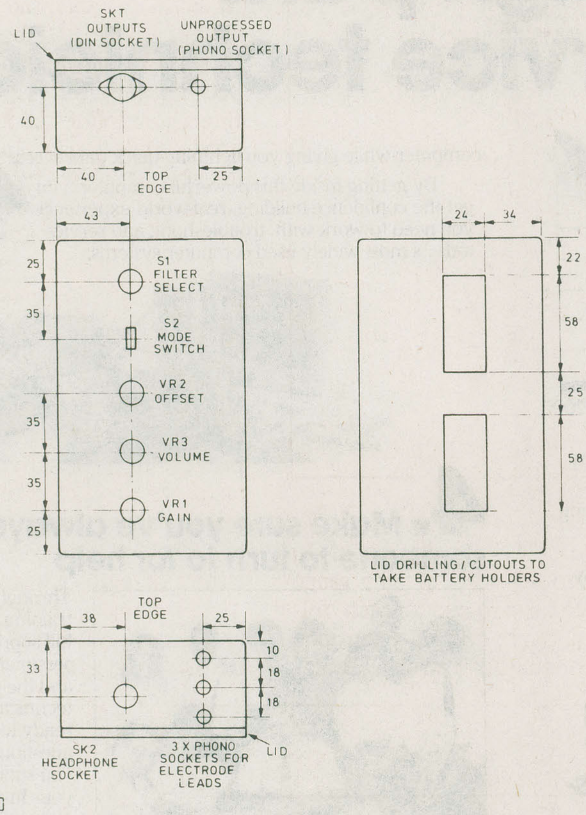


Fig. 7. Case drilling details.

shorted to the ground point between them, the 100ohm trimmer VR1 set to about half-travel, and the first two OP-07s, IC1 and IC2 inserted. This will raise the supply current to about 7.5mA. Their output voltages (pin 6) can be checked, and the effect of VR1 noted. It should be possible to zero both outputs with VR1, though allowance should be made for the slow response. (This check initially failed on the prototype, revealing a faulty OP-07).

After this IC3 can be fitted, raising the current to about 9.5mA. With a meter connected to test point 1, IC3 output, VR1 should be carefully adjusted for zero voltage. Inserting IC4 should raise the supply current to the final value of about 10.5mA, and the test point 2, IC4a output, should also be at 0V.

A fairly tricky adjustment follows, the setting of VR2 for best hum rejection. To avoid problems of spurious hum pickup during this adjustment the board should be placed on an insulated conductive surface, to which its ground rail must be connected. A sheet of kitchen foil overlaid with cardboard will suffice. The inputs should be disconnected from ground but coupled together and a 60Hz input applied to them.

If a signal generator is available this input should be about one volt RMS — if not, a finger placed on them will probably inject about the right level in most workshops. A means of monitoring test point 1 is required, ideally an oscilloscope, though a millivoltmeter will do. Most DVMs have a suitable range (no serious constructor today should be without one). VR2 should be trimmed for minimum AC output at the test point. If the optimum adjustment is difficult to find, hum is probably still being induced into the circuit from some external source.

This adjustment proved almost impossible on the prototype until the grounded conductive sheet was set up as described, when it became easy. If a scope and generator are available, test point 2 can be monitored while the frequency is varied and the effect of the filter observed, although this is not essential. A final check on the adjustment of VR1 is advisable.

The completed front-end PCB may be used on its own for experiments if desired, though the comments on shielding, given in the description of final assembly, should be noted.

Construction — Second PCB

Assembly of the second PCB is simpler than that of the first. The layout is gien in Fig. 6. Again the sockets should be used for the ICs, and CMOS handling precautions observed for IC3. Since testing requires most of the controls to be connected, it is as well to complete it and assemble the entire project into the case, an ABS box, size 190 X 110 X 60mm, before commencing.

As the layout is fairly compact full case drilling details are given in Fig. 7. The layout of controls, sockets and PCBs is shown in Fig. 8, while their connections appear in Fig. 9. The Delta/Alpha/Theta switch S1 has a fourth position, Off, which controls battery supplies to both printed circuit boards. The front-end PCB has shields placed to either side and connected to the input ground point. Spare pieces of PCB material, with the copper facing outwards, are ideal, but suitably insulated sheet metal or even stiff card and kitchen foil could be used.

Note that when boards and controls are placed as shown, there is room for the two snap-in battery holders to fit between them. Four stick-on rubber feet keep these holders clear of surfaces on which the unit is placed.

Testing — Second PCB

Testing of the second PCB can proceed as follows. First it should be powered up by itself, without ICs except for the regulator IC5. Following an initial surge the supply current should settle to about 5mA. The presence of 5 volts across C19 can be checked. IC4 should now be fitted, raising the drain by a couple of milliamps. With a 9 volt supply the voltage at IC4's output, pin 6, should be about 4.5 volts.

If the headphones are connected and a finger placed on the bottom of the 100n capacitor C15, a loud hum will probably be heard. The same finger on the top of the 10uF capacitor C12 (or pin 4 of IC3's socket), should cause a softer hum, adjustable with volume control VR3. IC3, the 4046B chip, can now be fitted and S2 switched to integrate. This should produce a horrible noise, half hum and half tone. Connecting pin 8 of IC2's socket to negative supply should produce a clear, steady, low frequency tone, while taking it to the 5 volt positive supply will result in a higher tone, slightly more than an octave up.

Next the TL064, IC1, can be fitted, and

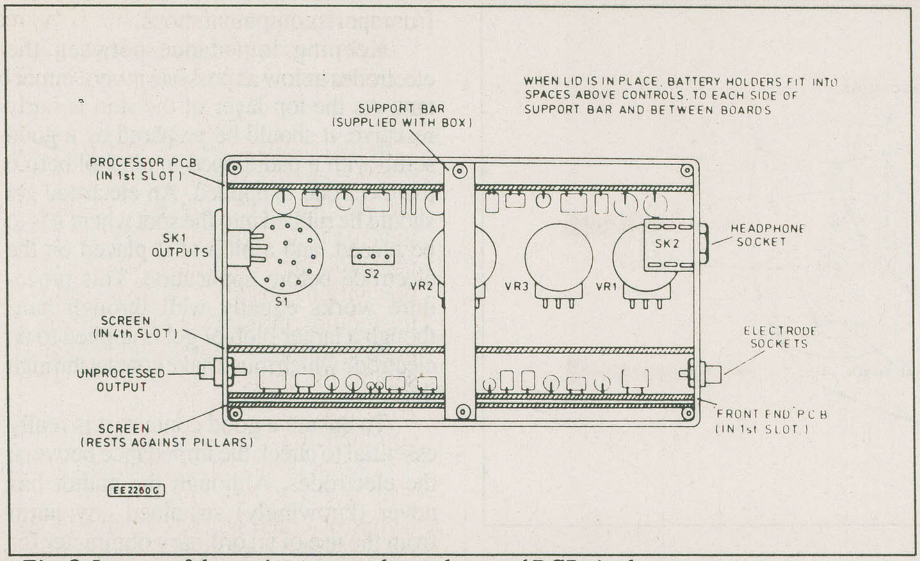


Fig. 8. Layout of the various controls, sockets and PCBs in the case.

S2 set to direct. All three on positions of the selector switch S1 should produce clear, steady tones. IC1's outputs, pins 1, 7, 8 and 14, should be checked as being about 2.5 volts; being the four corner pins they're easy to locate. Touching the top of 1u capacitor C1 to +5 volts on any range should produce a sharp rise in pitch, followed by a return to the original output tone during which ringing at the selected Brainwave frequency should be clearly audible.

Finally IC2, the LM324, can be fitted, S2 set to integrate, and the effect of offset control VR2 tried. About halfway around its travel this should start to increase the output frequency. Set just below this point, a finger touched to the top of C1, to inject hum, should produce a rise in pitch. The total current drawn by the complete board should be around 7 to 8mA, though this will depend to some extent on output volume.

Finally, the front-end board should be powered, the gain control VR1 turned right down, and the voltage across R1 (and VR1) checked as being about one volt DC. If the circuit is set to integrate, advancing VR1 should cause a rise in output pitch as noise finds its way into the open-circuit inputs. A finger placed over them should increase this output. The final supply current drawn by the output board should be about 10mA, the increase being due to the current drawn by the opto-isolator and R1.

The project is now operational and can be put to use as soon as suitable electrodes have been prepared.

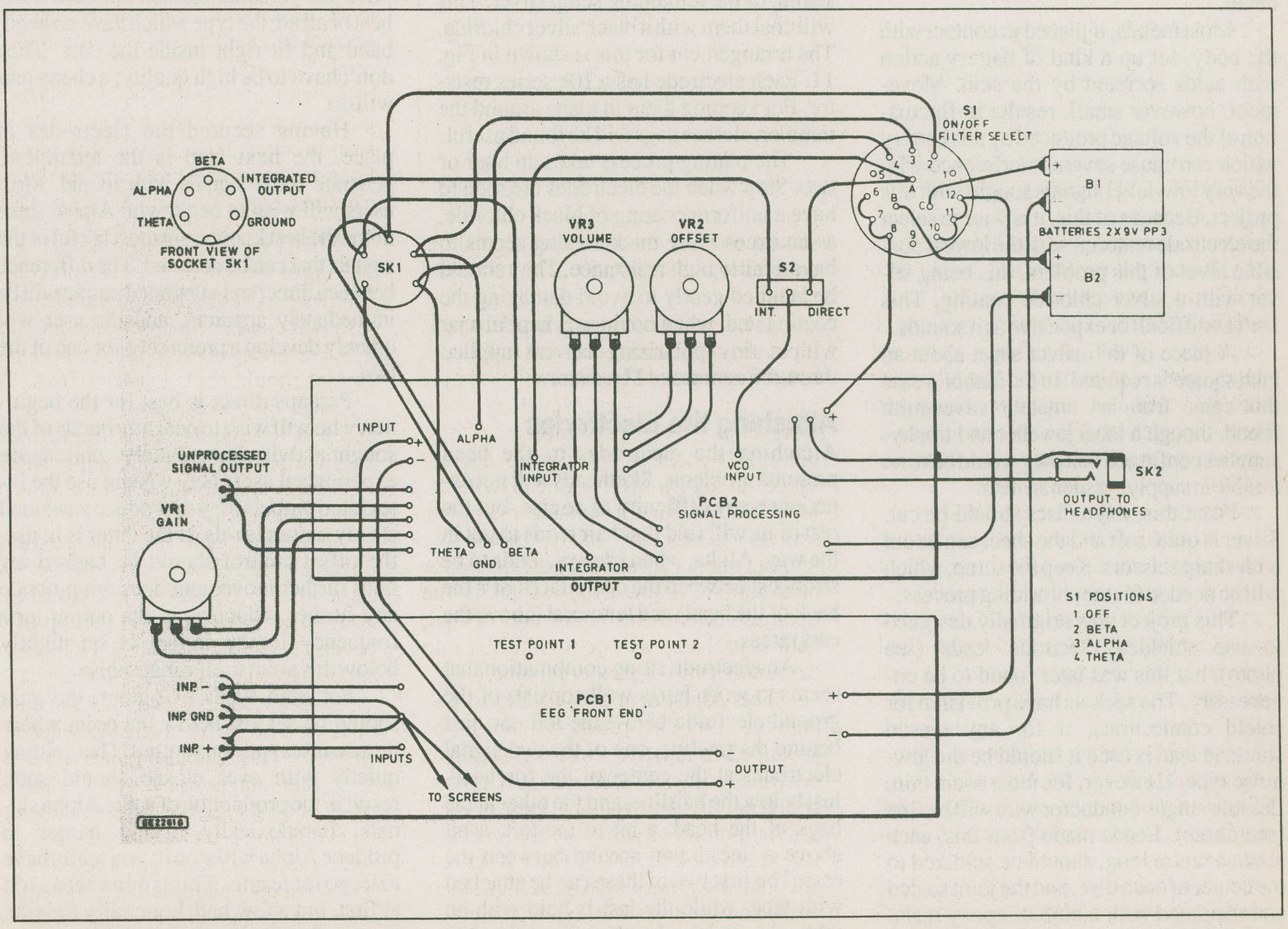


Fig. 9. Interwiring of the monitor.

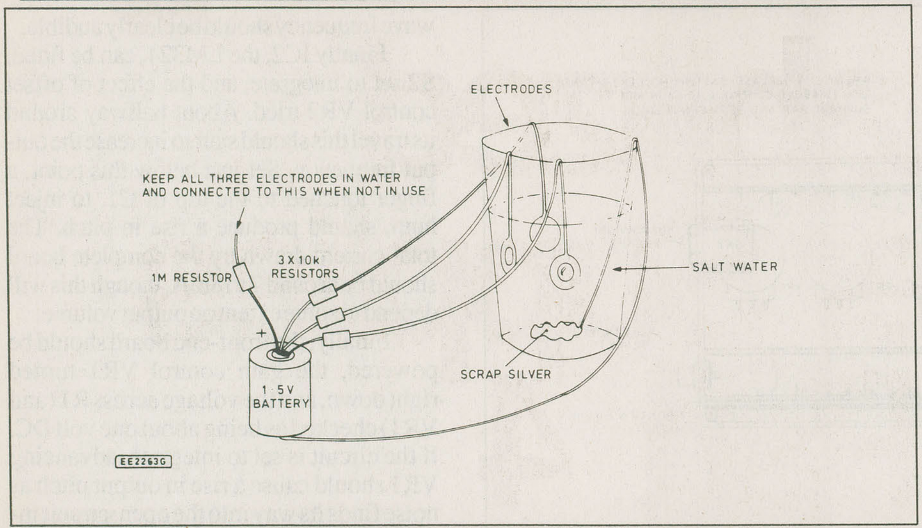


Fig. 10. Setup for plating the electrodes.

Electrodes

A large factor in the successful operation of this project is the manner in which its electrodes are made and used. It follows that considerable care should be taken with these, so they will be covered in some detail.

Most metals, if placed in contact with the body, set up a kind of battery action with acids secreted by the skin. Movement, however small, results in fluctuation of the voltage produced by this battery which can cause severe interference with the very low-level signals sought with this project. Because of this, it is wise to select the electrode material with the lowest possible level of this problem, this being silver with a silver chloride coating. This isn't as difficult or expensive as it sounds.

A piece of thin silver sheet about an inch square is required. In the author's case this came from an amateur silversmith friend, though a local jeweller and trophy-supplier confirmed that they would have no trouble in supplying such an item.

From this, three discs should be cut. Silver is quite soft and the sheet can be cut with sharp scissors. Keep the scrap, which will be needed for the chloriding process.

This project was originally designed to use shielded electrode leads (see photo), but this was later found to be unnecessary. The sockets have provision for shield connections; if for any reason shielded lead is used it should be the low-noise type. However, for most users thin, flexible single-conductor wire will be fine (see photo). Leads made from this, each about a metre long, should be soldered to the center of each disc, and the joint sealed and insulated with a blob of epoxy resin. Fig. 10 shows this.

The other side of each disc should be thoroughly cleaned before the chloriding process. This consists of placing them in a tumbler of water containing a teaspoon of dissolved salt, and passing a small current through them to a common electrode consisting of the remaining scrap silver. This will coat them with a black silver chloride. The arrangement for this is shown in Fig. 11. Each electrode has a 10k series resistor. For keeping them in place around the tumbler, clothes pegs will be found useful.

The plating process takes an hour or two. Stop when the electrodes are seen to have a uniform coating of black chloride, as an excessively thick coating seems to have a fairly high resistance. They should be handled gently to avoid damaging the coating and, when not in use, kept in a jar with a tiny polarizing current applied through a common 1M resistor.

Attaching the Electrodes

Attaching the electrodes to the head presents problems. Skinheads will not experience any difficulty of course, but the rest of us will find that hair tends to get in the way. Alpha, when present, tends to be strongest between the occipital (that's the back of the head) and temporal (above the ears) areas.

An electrode siting combination that seems to work fairly well consists of the ground electrode below the left ear, just behind the jawline, one of the two signal electrodes at the center of the forehead, just below the hairline, and the other at the back of the head, a bit to the left, a bit above a line drawn around between the ears. The first two of these can be attached with tape, while the last is held with an athlete's elastic headband, obtainable from sports equipment shops.

Keeping impedance between the electrodes as low as possible is very important. As the top layer of the skin is fairly resistive, it should be prepared by a good scrub with a pad dipped in alcohol before the electrode is applied. An electrode gel should be rubbed into the spot where it is to be placed, and a blob of it placed on the electrode before application. This procedure works equally well through hair, though a larger blob of gel is applied to an electrode which must make contact through this.

To ensure a good contact, it is really essential to check the impedance between the electrodes. Although the author has never (knowingly) sustained any harm from the use of an ordinary ohmmeter for the job, this is not going to be recommended here.

In Use

Ordinary headphones can be used with this project, but may tend to get caught up in the electrode leads. The miniature type supplied for personal stereos are better, but best of all are the type which have no headband and fit right inside the ears. They don't have to be high quality; a cheap pair will do.

Having secured the electrodes in place, the next step is the attempt to generate some signals with its aid. Most users will wish to begin with Alpha, since this is the best known and most useful of the signals that can be detected. The difference between direct and integrated output will be immediately apparent, and the user will quickly develop a preference for one of the two.

Perhaps direct is best for the beginner, who will wish to hear any bursts of the sought activity immediately, while more experienced users may wish to use the integrated output to try to produce sustained steady output levels. If the latter is in use, the offset control should be backed off until further movement does not produce any further reduction in the output tone frequency. It may, in fact, be set slightly below this point to eliminate noise.

For both types of output, the gain should be set just below the point where noise causes spurious output. Then, sitting quietly with eyes closed should soon result in the production of some Alpha signals. Paradoxically, trying harder to produce Alpha will stop it; you really have to let go for results. This is quite hard to do at first, but a few half-hour daily training session should soon produce the knack ■

Stabilized Power Supplies Part 4

Using the 723 to demonstrate a comprehensive 25V 2A power supply.

STEVE KNIGHT

A great variety of integrated circuit power regulators and indeed complete power supply systems are available these days, and earlier on we looked at the 78/79 series and their applications as fixed voltage regulators. It sometimes happens that we have a voltage regulator which has a first class specification, but does not supply us with as much current as we would like.

The LM723 14-pin DIP regulator is a case in point; it has a good ripple rejection with excellent load and line regulation, and an in-built current limiting facility. But its current output is restricted to a maximum 150mA.

This month we conclude the series by looking at a power unit design that makes use of the 723 as a driver unit for a beefier control system, one which will give us an output current of 2A while retaining the other desirable features of the 723 intact.

Regulator

The LM723 regulator, the pin connections of which are shown in Fig. 1, is a complete circuit system of the type already described, containing a series of emitter-follower controller, a current limiting transistor, together with an error amplifier and reference voltage. Most parts of the circuit are made available at the pins and a variety of different connections can be made to provide a variety of stabilized output voltages.

The basic internal circuitry of the 723 is shown in Fig. 3. By now, this should be a familiar system.

The reference voltage is derived from a constant current source and is available at pin 6. By connecting pin 6 to pin 5, the reference voltage can be applied to the

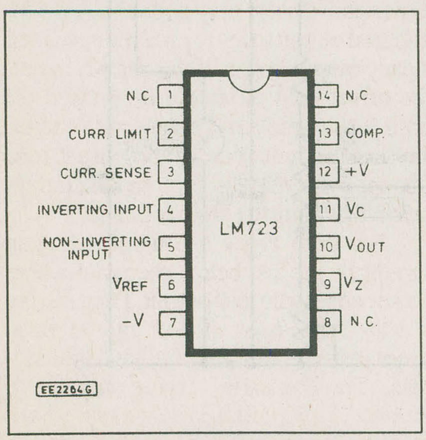


Fig. 1. Pinout details of the 723.

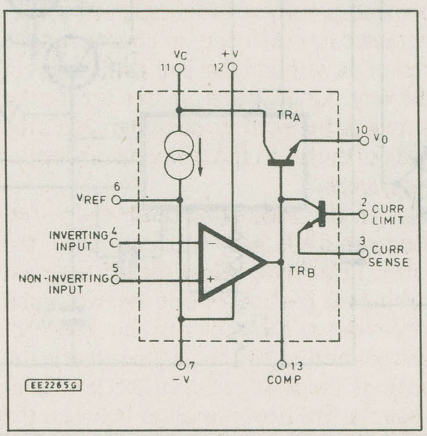


Fig. 2. Internal circuitry of the 723.

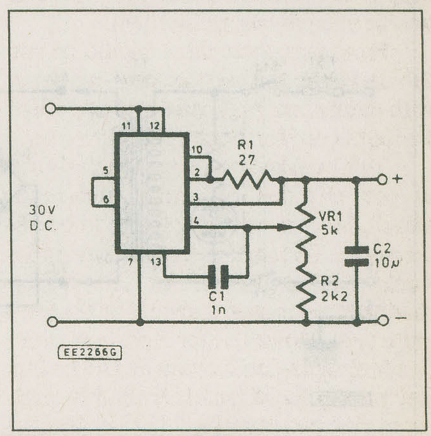


Fig. 3. Basic circuit using the 723 regulator to provide an adjustable low-current output.

Stabilized Power Supplies, Part 4

non-inverting input of the error amplifier.

The inverting input is brought out to pin 4 and if this is controlled by a voltage derived from the output of the power supply, the difference will be detected by the amplifier and its output used to control the internal series regulator TR$_A$. This output is also brought out to pin 13 so that a compensating capacitor can be connected to the inverting input; this capacitor reduces the high frequency gain and maintains stability over the internal feedback system.

A current limiter, TR$_B$, is provided to take care of the effects of heavy load currents or short-circuits at the output, pin 10. This transistor senses the voltage developed across a resistor in series with the output (which in turn depends upon the current being drawn) and begins to conduct when the voltage is about 0.65V. As TR$_B$ conducts, it puts a low resistance bypass across the base-emitter junction of TR$_A$, rendering it inoperative and shutting off the supply of current to the output.

So we have here, with the addition of a few external components, a complete power unit which will, using the values indicated in Fig. 3, provide us with an output ranging from about 5V to 25V. However, there are problems of dissipation to think about — we cannot expect to be able to draw large currents from a small IC package.

As we have noted, the 723 has a maximum permissible current rating of 150mA and a maximum permissible power dissipation in TR$_A$ of 660mW at an ambient temperature of 25°C. This derates by 5.6mW/°C, so if we operate at the maximum temperature of 70°C allowed for by the manufacturers, we have lost about 250mW of our available power as internal heat. At 150mA output, we need have only 660/150 = 4.3V across TR$_A$ before the power rating is exceeded.

In the circuit of Fig. 3, if we set the output to 5V, then there will be 25V across the regulator and the maximum current will be restricted to 660/25 = 26mA. So on its own, the 723 is rather restricted in its capabilities. This does not mean that the 723 is not an effective regulator in its own right; it is, and for outputs requiring relatively small currents it is an excellent device.

Strictly speaking, circuits of the kind shown in Fig. 3 should be used to provide *fixed* outputs rather than variable./ This then enables the maximum current to be calculated and so reduces the chances of it being inadvertently exceeded, as might well happen with a variable output.

Increasing Output Current

We can boost the output current if we use the 723 to drive an external emitter-follower as a series regulator. The internal current limiting facility can be retained and from this we can arrange a series of discrete current limiting levels at the output.

This has an advantage over the previous designs in this series; while the earlier circuits had short-circuit protection, there was nothing to prevent the full output current flowing into the load when a fault condition appeared, whether accidental or not. So although the power unit was protected, the attached current was not. A heavy current could still be capable of doing some damage in whatever piece of equipment was attached to the power supply.

In this design, the current output in the event of a short- circuit or excessive load, can be limited to any level you care to choose within the total range of current available, that is. 0 to 2A. The actual levels are simply a matter of your own personal preference.

Variable Stabilized Power Supply

The PSU is variable from 1.5V to 25V, with four switched current limits of 0.5A, 1A, 1.5A and 2A. The circuit diagram of

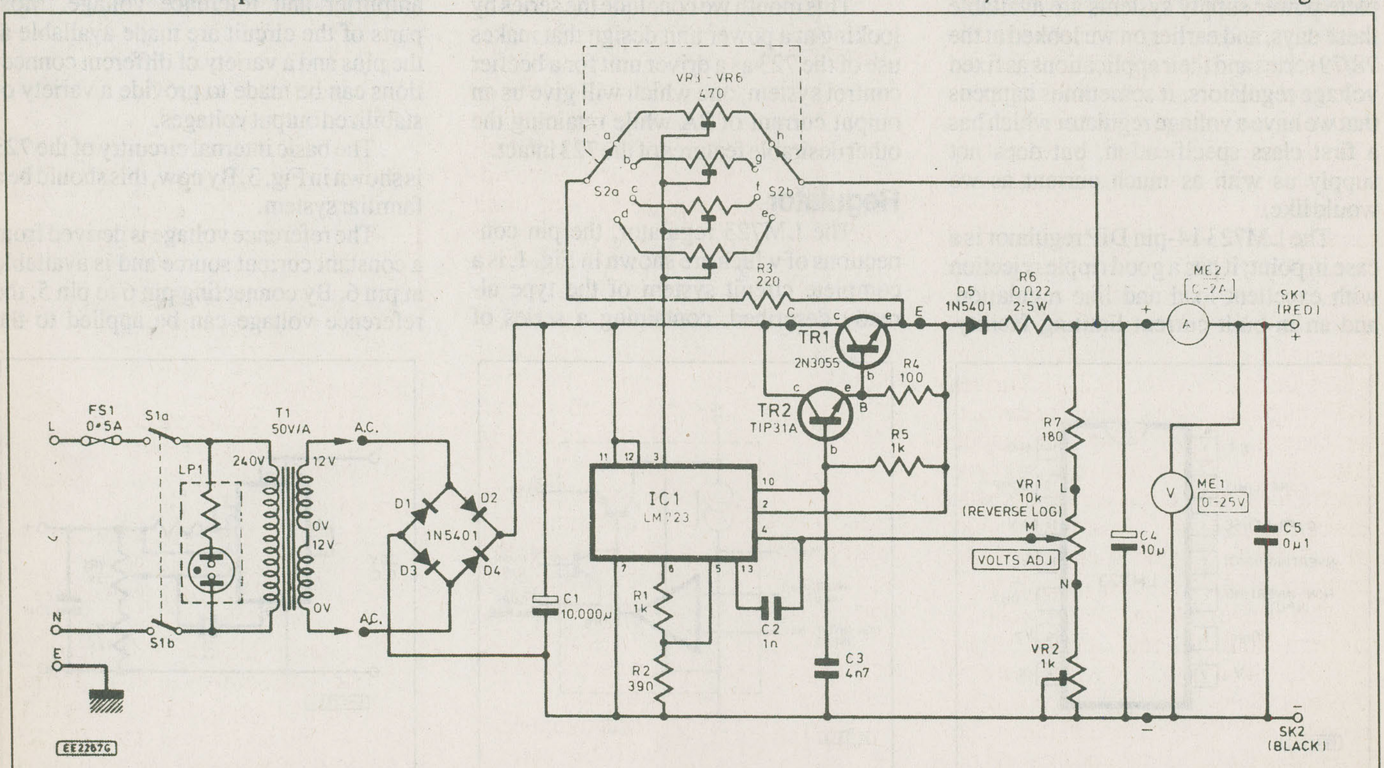


Fig. 4. Complete circuit diagram for the 1.5V/25V Variable Power Supply. The solid circles refer to circuit board connection points.

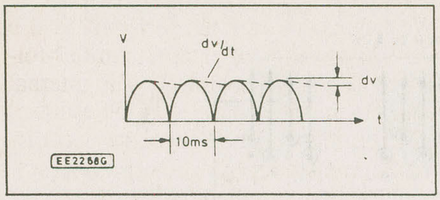


Fig. 5. Ripple voltage caculations for capacitor C1 selection.

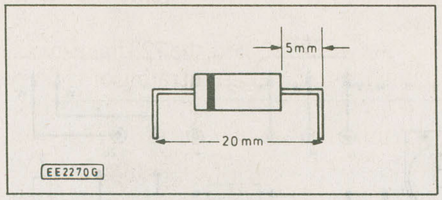


Fig. 7. Using longnose pliers, bend the diode leads to suit hole spacing.

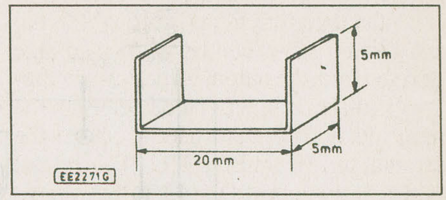


Fig. 8. Alternative heatsink dimensions for IC1.

the 2A power unit is shown in Fig. 4. Here a conventional bridge rectifier feeds the 723 (IC1) which in turn drives the power booster combination of transistors TR1 and TR2. Transistor TR1 (a 2N3055) is the conventional series emitter-follower controller which is itself driven by TR2, a small power transistor, type TIP31A. This is necessary as the output of IC1 (723) is insufficient to drive TR1 directly.

Resistor R6, in conjunction with diode D5, forms the current sensing resistor and a portion of the voltage developed across this arrangement is tapped off by one of the potentiometers VR3 to VR6 and applied to the current sensing input pin 3 of IC1. This determines the point at which the current output is limited.

The effect of diode D5 is that, being non-linear, the effective resistance of the sensing combination increases with lower current outputs and maintains a sufficient voltage across the potentiometers to ensure proper operation of the limiter in the 723 regulator. By selection of the potentiometers by ganged switches S2a and S2b, four current levels can be preset.

The output voltage is adjusted between about 1.5V and 25V by VR1 which connects to the inverting input (pin 4) of the error amplifier. This compares output variations with the internal reference, selected by the divider chain made up of resistors R1 and R2, and adjusts the output at the base of Transistor TR2. TR2 drives TR1 which then compensates for the output change, so stabilizing the output. Potentiometer VR1 is a *reverse* log type which allows a closely linear relationship between rotation angle and output voltage. A linear potentiometer leads to cramping at the lower end of its rotation.

The bridge rectifier (D1-D4) is made up from four discrete diodes, types 1N5401, which are 3A devices rated at 100Vrms. Smoothing is carried out by capacitor C1. This capacitor has to be rather large if a 2A output capability is required; taking it that the maximum input ripple voltage to the 723 regulator should not exceed 2V when the full current is being drawn, then since ripple gradient $dV/dt = 1/C$ (see Fig. 5) and $dV = 2V$, $dt = 10ms$ for 50 Hz supplies, we get $C = (2 \times 10^{-2})/2 = 10k\,uF$.

We also need a ripple current rating of at least twice the average worst case ripple current we are likely to draw from the capacitor. Therefore, for this unit we need a ripple rating of at least 4A. The specified capacitor has a rating of 5A which gives us something in hand. If you use an alternative capacitor, keep these figures in mind.

It is suggested that both voltage and current meters be fitted to the complete unit. A voltmeter is almost certainly necessary and an ammeter is well worth inclusion. The circuit for the two meters is shown between the Volts Adjust control and the output terminals in Fig. 4. These are wired between the board output terminals and the front panel of the unit. If the specified meters are used, no rescaling is necessary.

Construction

All components are mounted on a single-sided printed circuit board except the mains transformer T1, the power controller transistor TR1, the Output Voltage Adjust control VR1 and the Current Limit switch S2.

The printed circuit board component layout and a full-size copper foil master pattern is given in Fig. 6, with an indication of the wiring from edge Vero pins to the various external components and controls. The lettering on the board matched that shown on the circuit diagram and Fig. 10.

There are one or two points of importance to be noted about mounting components on the board. The first concerns capacitor C1. This is a PCB mounting type of capacitor and the component used has five fixing pins. Only two of these are for the positive and negative connections, the other three *must* be left isolated.

If you use the specified component, the board positions will be correct. However, you may obtain, or already have, an alternative capacitor; in this case the board will have to be drilled to accommodate the alternative pin arrangement.

Parts List

Resistors

R1,R5 1k
R2 390
R3 220
R4 100
R6 0.22 2.5W
R7 180
All 0.25W metal film, except where stated.

Potentiometers

VR1 10k reverse log.
VR2 1k min. preset, hori.
VR3-VR6 470 min. preset, hori.

Capacitors

C1 10,000u 40V 5A
C2 1n polyester
C3 4n7 polyester
C4 10u tantalum 35V
C5 0u1 polyester

Semiconductors

D1-D5 1N5401 3A 100V rec.
TR1 2N3055 or 2N3771 *npn* power
TR2 TIP31A *npn* power
IC1 LM723 regulator

Miscellaneous

S1 DPDT power toggle
S2 3-pole 4-way rotary
T1 25V/3A transformer, centre-tapped
ME1 0-25V moving coil meter
ME2 2A moving coil meter
LP1 220-250V neon indicator

PCB; case, 305mm X 159mm X 133mm; heatsinks; 14 gauge aluminum (see text), clip-on (for IC1, RS434-059) and finned (for TR2, RS 403-162); SK1, SK2 4mm type, 1 black, 1 red; 500mA cartridge fuse; connecting wire; solder, etc.

Stabilized Power Supplies, Part 4

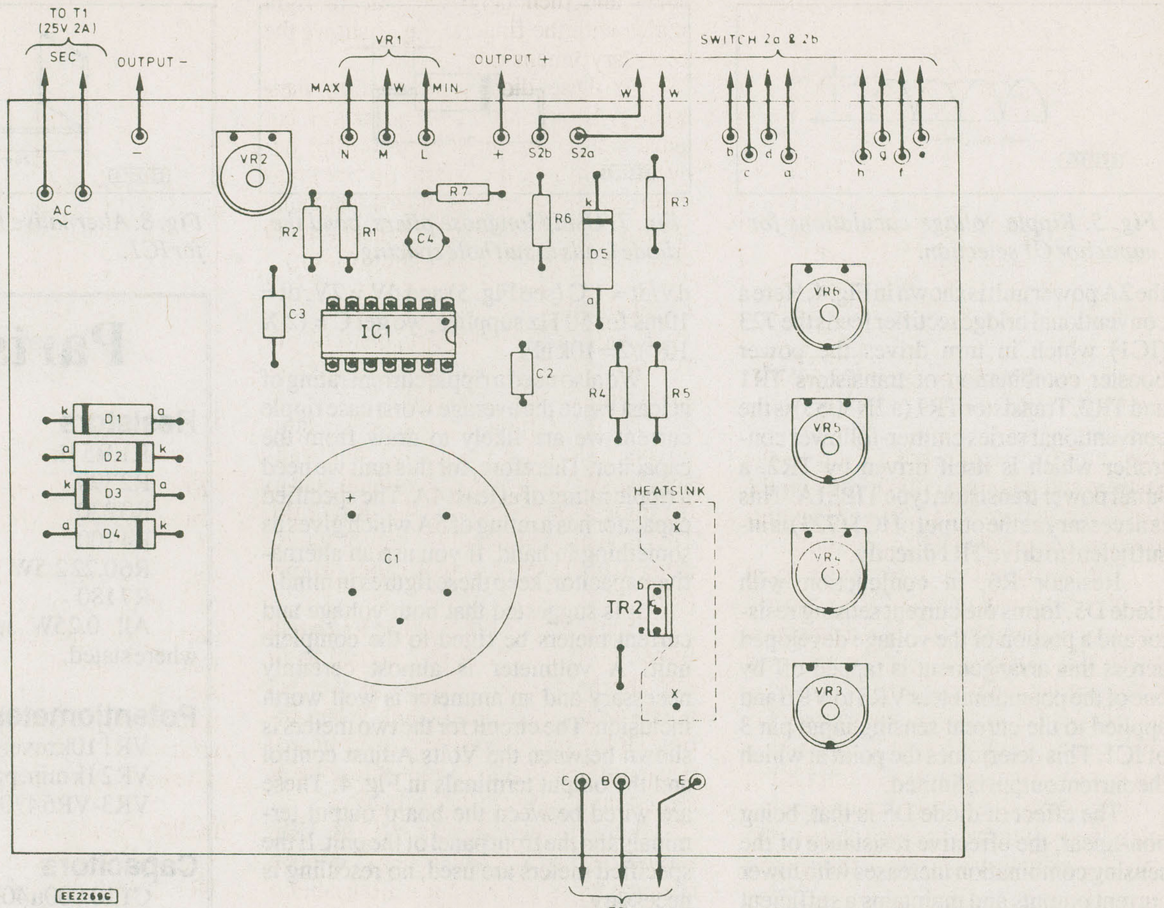
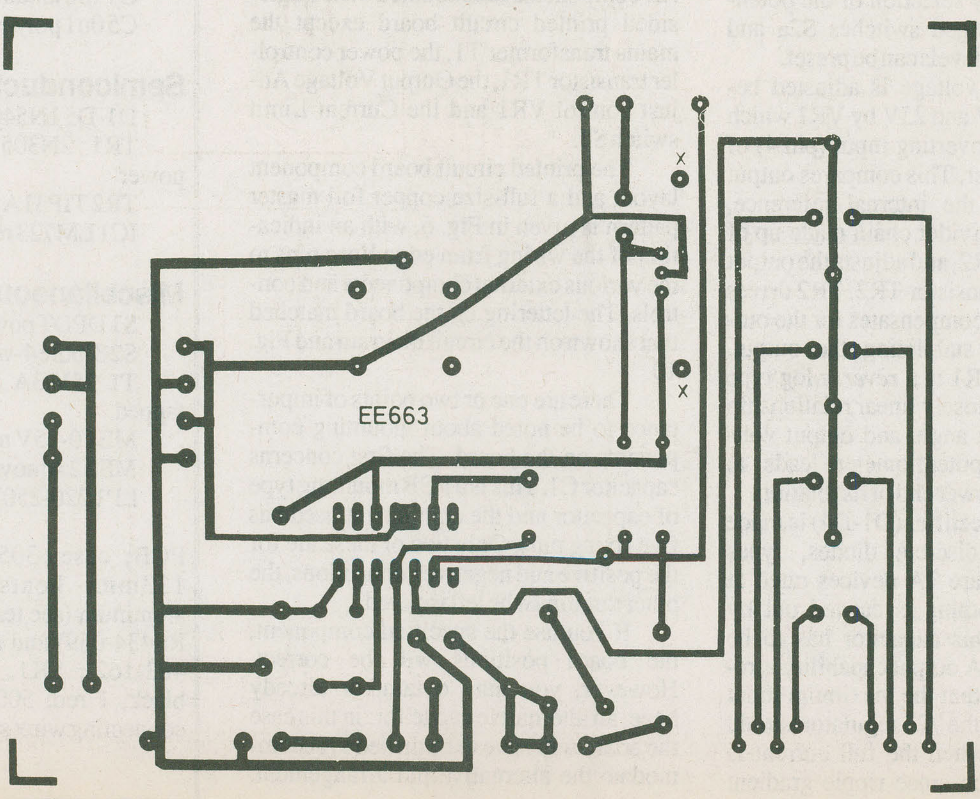


Fig. 6. The printed circuit and parts overlay for the 25V/2A supply.



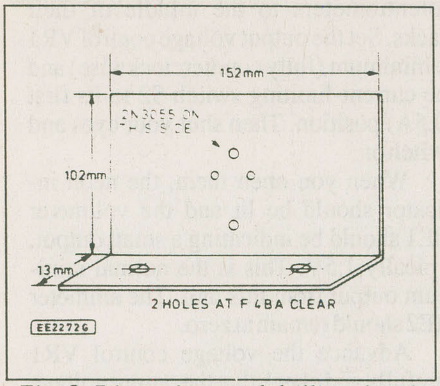


Fig. 9. Dimensions and drilling details for the heatsink.

This may necessitate linking up to the positive and negative copper rails on the board with a short length of wire but this should not be too difficult to cope with.

The essential thing is the physical size of an alternative; height is not too important, but diameter is. If the diameter is greater than some 45mm, there may be a problem of accommodation.

Diodes D1 to D4 and the solitary D5 have rather thick (1.3mm) connecting wires and great care must be exercised in bending these to suit the board spacing holes. It is best to grip the wire close to the body of the diode with a pair of thin-nosed pliers and then bend the wire at right angles with the fingers. Fig. 7 shows the necessary dimensions.

Fit these diodes snugly into their board positions, *noting the polarities*, but leave a space of about 3mm (1/8in) between them and the board; do *not* press them down hard on to the board. The same applies to the 2.5W resistor R6; let it stand clear of the board by at least 5mm (3/8in).

Heatsinks

The regulator IC1 needs a standard 14-pin DIP holder and a heatsink. The driver transistor TR2 also has a heatsink.

The regulator IC1 should have a clip-on type of heatsink but if this is not available, a piece of 16 gauge aluminum bent to the dimensions shown in Fig. 8 will do. This is simply glued to the top of the IC using a thin layer of a quick setting epoxy resin.

Transistor TR2 is attached to a small finned heatsink which is designed to fit into the board and soldered at the two points *X-X* (see photographs). When fitting TR2 to its heatsink (and to the board) take care that the three connecting leads are not shorting out to the heatsink.

Preset potentiometers VR3 to VR6 should be the enclosed rather than open skeleton types, but you can use the latter if

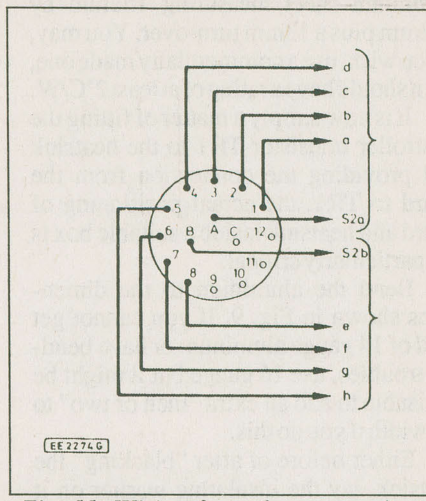


Fig. 11. Wiring from the current-limit switch S2 to the circuit board.

you can't get hold of anything else. The rest of the components need no special comment. The usual care in soldering must be followed for the whole of the assembly, and watch out all the time for solder bridges and splashes, particularly around the IC connections and all parts where the copper track spacing are close.

Main Heatsink

The main heatsink for the power transistor TR1 is made out of a piece of 14 gauge

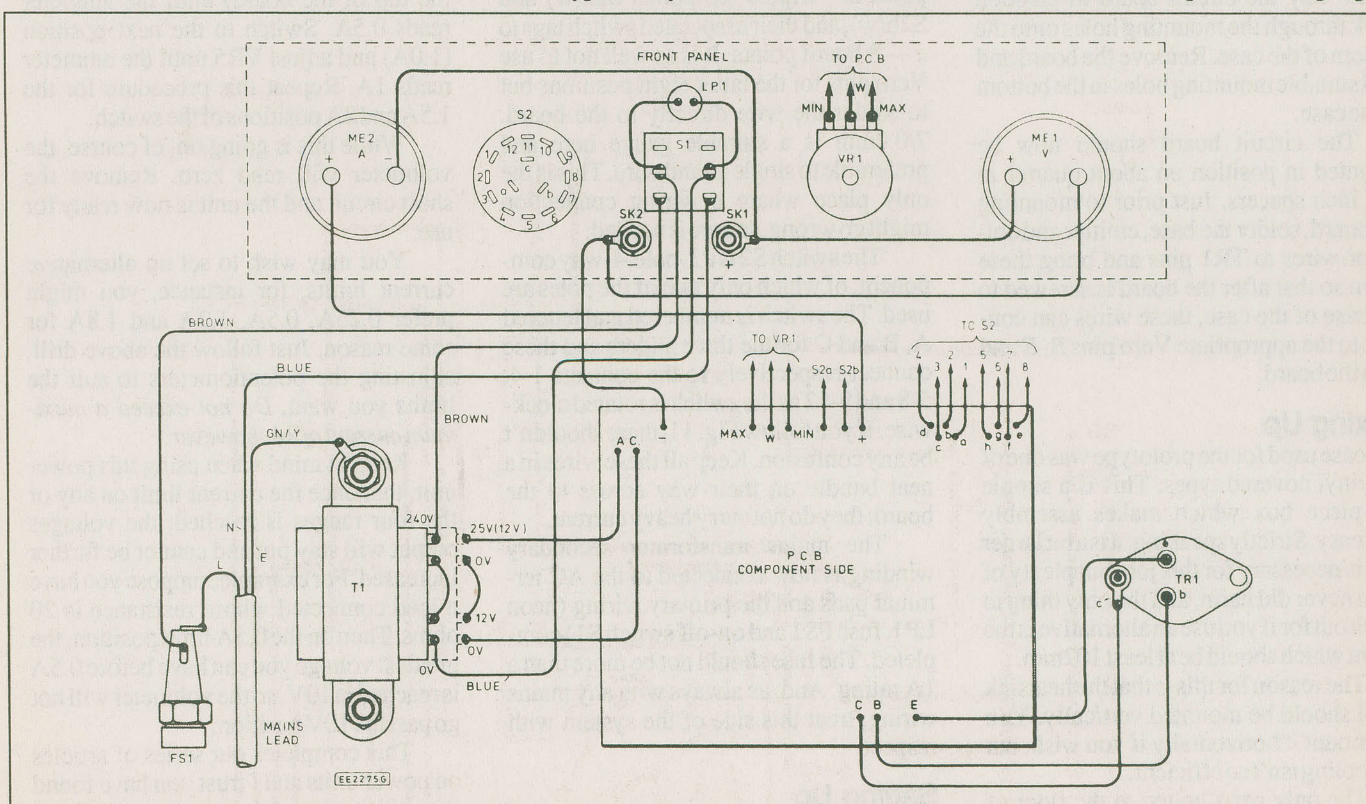


Fig. 10. Interwiring from the circuit bpoard to the front panel components, TR1, fuse and transformer. Note that capacitor C5 can be wired directly across the output terminals or across the voltmeter terminals.

aluminum sheet measuring 152mm by 102mm plus a 13mm turn-over. You may, if you wish, use a commercially made one, but it should have a rating of at least 2°C/W.

It is now simply a matter of fitting the controller transistor TR1 to the heatsink and providing the connection from the board to TR1, the actual positioning of board and heatsink inside a suitable box is not particularly critical.

Bend the aluminum to the dimensions shown in Fig. 9. If you cannot get hold of 14 gauge aluminum or have bending troubles, use 16 gauge but it might be advisable to add an extra "inch or two" to the width if you do this.

Either before of after "blacking" the heatsink, lay the insulating washer on it and mark through the three pinout hole positions on the heatsink. Drill the heatsink and mount the 2N3055 transistor slightly below center on the heatsink, using the insulating kit.

Position the heatsink at one end of the base of the case and mark through and drill suitable mounting holes in the bottom of the case. Mount the mains transformer at the other end of the case as indicated in the photographs.

There should now be enough space between the heatsink and mains transformer to take the completed circuit board. Lay the circuit board in position mark through the mounting holes onto the bottom of the case. Remove the board and drill suitable mounting holes in the bottom of the case.

The circuit board should now be mounted in position on about quarter to half inch spacers. Just prior to mounting the board, solder the base, emitter and collector wires to TR1 pins and bring these down so that after the board is screwed to the base of the case, these wires can connect to the appropriate Vero pins *B*, *E* and *C* on the board.

Boxing Up

The case used for the prototype was one of the vinyl covered types. This is a simple two-piece box which makes assembly very easy. Strictly speaking, it is a bit larger than is necessary for this job, but plenty of room never did harm, and the only thing to watch out for if you use an alternative is the height which should be at least 102mm.

The reason for this is that the heatsink panel should be mounted vertically. You *can* mount it horizontally if you wish, but the cooling isn't so efficient.

The only parts bolted to the floor of the case are the heatsink, circuit board and the mains transformer. Everything else is on the front panel, apart from the fuse which is best mounted at the rear, alongside the entry point for the mains cable.

A suggested front panel layout is shown in the photograph above. As the box is a plain aluminum finish, it is well to give a coat of suitable spray paint before attaching Letraset style lettering. The "current limit" ranges are shown as 0.5A, 1.0A, 1.5A and 2.0A. These can, in fact, be any values you like, so if you want other levels, mark your panel accordingly. Setting these levels up is discussed later.

Interwiring

The interwiring connections are made in accordance with the circuit diagram Fig. 4, board layout Fig. 6 and Fig. 10. It is best to start by wiring up the meters and connecting these to the positive (+) and negative (-) output points on the board. Use flexible 16/0.2mm wire for this.

Next, connect the pins *L, M and N* on the board to the Voltage Adjust control potentiometer VR1, noting that the *maximum* output voltage is obtained when the slider is at the VR2 end of the track. As already indicated, this control should be a *reverse* log potentiometer.

Wire two of the current limit switch poles or "wipers" to points S2a(w) and S2b(w), and their associated switch tags to *a — h* board points. It is as well not to use Vero pins for the latter eight positions but to solder the wire directly to the board. 7/0.2mm is a suitable gauge here and preferable to single strand wire. This is the only place where a wiring connection might go wrong, so care is needed.

The switch S2 is a 3-pole, 4-way component, of which only two of the poles are used. The switch is numbered and lettered A, B and C for the three sliders and these connect respectively to the contacts 1-4, 5-8 and 9-12 as the switch is rotated clockwise. If you follow Fig. 11, there shouldn't be any confusion. Keep all these wires in a neat bundle on their way across to the board; they do not carry heavy current.

The mains transformer secondary winding is now connected to the AC terminal pads and the primary wiring (neon LP1, fuse FS1 and on-off switch S1) completed. The fuse should not be more than a 1A rating. And, as always with any mains wiring, treat this side of the system with respect.

Setting Up

To set up the unit, first of all turn all preset potentiometers to the middle of their tracks. Set the output voltage control VR1 to minimum (fully counterclockwise) and the current-limiting switch S2 to its first (0.5A) position. Then shut your eyes and switch on.

When you open them, the neon indicator should be lit and the voltmeter ME1 should be indicating a small output, typically 1.5V. This is the normal minimum output from this unit. The ammeter ME2 should remain at zero.

Advance the voltage control VR1 carefully and check that the output voltage increases. When the control gets to its maximum position, adjust preset VR2 so that the voltmeter reads 25V. this completes the voltage setting.

Current Limiting

If all this has happened uneventfully and there has been no sign of circuit discontent, we can now get on with setting up four current-limiting stages. This procedure is best done fairly quickly, not that any damage is going to result if you happen to be slow, but unnecessary heating will be avoided.

Make sure that the current limit switch is in its most counterclockwise position (corresponding to the 0.5A limit), then put a temporary short circuit across the output terminals. Adjust VR6 (nearest the top of the board) until the ammeter reads 0.5A. Switch to the next position (1.0A) and adjust VR5 until the ammeter reads 1A. Repeat this procedure for the 1.5A and 2A positions of the switch.

While this is going on, of course, the voltmeter will read zero. Remove the short circuit and the unit is now ready for use.

You may wish to set up alternative current limits, for instance, you might prefer 0.25A, 0.5A, 1.2A and 1.8A for some reason. Just follow the above drill, adjusting the potentiometers to suit the limits you want. *Do not exceed a maximum current of 2A, however.*

Keep in mind when using this power unit, that once the current limit on any of the four ranges is reached, the voltages output will stay put and cannot be further increased. For example, suppose you have a load connected whose resistance is 20 ohms. Then on the 0.5A limit position, the greatest voltage you can have before 0.5A is reached is 10V, so the voltmeter will not go past the 10V position.

This completes our series of articles on power units and I trust you have found something that fits your requirements among them.

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SECOND SNEAK

If you use a PC compatible computer, you've probably come to realize just how difficult it is to find really first class software for it. Commercial software is often hard to track down, and just because you have to pay for it doesn't necessarily mean it will work.

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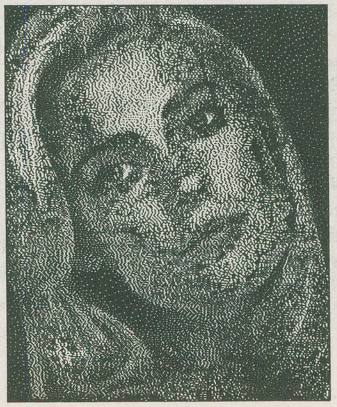
ALMOST FREE PC SOFTWARE™ VOLUME 54

This is a collection which will be especially useful to anyone who uses words. Aside from our usual assortment of first class software, these disks include several packages which lend themselves to word processing and desktop publishing. They feature a very sophisticated, expandable prose analyst and a first rate word processor which will quickly win a place in your heart and next to your fingertips.

There are also several powerful DOS utilities, a blast from the past and a complete computerized atlas. This is a two disk set which unpacks to over one megabyte of programs.



SOAPBOX is a complete, exceedingly powerful word processor which is fast enough to use on a stock XT and small enough to run in 256 kilobytes of memory. It's capable of emulating WordStar... It will even read and write WordStar files if you like... and it's loaded with first rate text basing features that make it ideal for use with a desktop publishing package.

HOWTALL will take into account your child's sex, age and other factors and tell you how tall he or she should be.

WORLD is a truly amazing computerized atlas which will do more things than a paper atlas ever could, including providing extensive EGA graphic maps, calculating the distance between major cities and so on. An EGA card is required.

CUTPASTE will allow you to cut text out one application and past it into another. It's very flexible and extremely useful for desktop publishing, word processing and spreadsheets. Source code is included.

SPATH allows you to search for things along DOS's search path just like DOS does. A handy little tool, this.

VIZ is a dynamite little screen speedup program for 80286 and 80386 based machines. It vastly reduces the amount of time required to print to the screen from many applications, making things like word processors and data base managers... not to mention DOS itself... seem to shift into warp drive.

EDISKEMS allows you to have a sophisticated EMS RAM disk with lots of features, including the ability to survive a warm boot with its data intact. Source code is included. Requires EMS.

MAXFIND is a great utility for finding strings within multiple text files. It includes a sophisticated search language to allow you to specify exactly what you want to search for.

ORGAN makes every key on your keyboard play a different note while you're running any application... or DOS. It's fun for a while, as well as being the ultimate in audible feedback.

More ☞

EZDOSIT is a memory resident file manager which allows you to pop up a window from within any application and work with your files. You can copy, delete and rename files, change directories and so on. It's a real time saver.

DESKNAV is a Microsoft Windows program which provides a number of facilities which Windows didn't see fit to include. This is one of the nicest desk managers we've encountered to date. Requires Microsoft Windows.

LANCE is a prose style analyzer. Far from just telling you that you use too many possessive pronouns, it lets you test a text file for specific characteristics, including sexual bias and potential libel. No writer should be without it.

DECIDE is a simple program to let you try out a number of potential colour schemes for Microsoft Windows and select the one which best suits you. Neon is the house favourite. Requires Microsoft Windows.

PCMAN is a small EGA version of PacMan with all the speed of the arcade version. However, this one just gobbles dots, not quarters. It's sort of nostalgic.

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INCOME TAX BUSTER

This collection includes a number of superlative programs. If you use spreadsheets at all we know you'll be particularly interested in the latest release of AsEasy, the premier shareware spreadsheet package which emulates Lotus and manages to go it one better in many areas. Accompanying AsEasy is KwikTax, a worksheet written to handle the tricky details of the 1989 Canadian income tax form.

In addition, you'll find some powerful utilities, a Tetris-like game that's better than the original and even a voice for your computer.

This is a two disk set which unpacks to over one megabyte of programs.

ASEASY is the latest version of the shareware spreadsheet package that has left the Lotus corporation shaking in its polyester boots. AsEasy is compatible with Lotus 1-2-3 and will use Lotus worksheet files. However, AsEasy is more powerful, easier to use and substantially cheaper. If you use Lotus you owe it to yourself to try AsEasy.

ATFLOPPY is a resident program which warns you if you attempt to write to a three hundred and sixty kilobyte floppy disk in a quad density AT drive. Saves considerable frustration.

WINDCHILL is a small program which calculates wind chill factors. This is a handy one to have when you want to justify staying inside during the winter.

QUOTE is a Windows application which says something clever each time it starts up. The clever things are stored in a dBase compatible DBF file, allowing you to use them in other applications if you like. Requires Microsoft Windows.

TALK is the most sophisticated computer speech system we've encountered for the PC. It includes a program to speak real digitized words through the speaker, source code thereof, a program to record your own speech fragments, the schematic for the requisite hardware for the recorder and lots of sample words which can be strung together at the command line. Quite a blast.

SNAP is a simple Windows camera. Copy any part of a Windows screen into the clipboard at the touch of a mouse button. Requires Microsoft Windows.

DAYLIGHT calculates the sunrise and sunset times, plus sundry related information, for any day at any point on earth. Good for things like headlight-on times. Includes source code.

WEIGHTS AND MEASURES is a handy program which will generate a table of weights, measures and conversions. Saves a lot of thumbing around.

BEYOND TETRIS is a really exciting variation on the popular Tetris games. Requires a VGA card... the graphics are stunning.

RTM is a personal scheduler program, to-do list and calendar. It can be memory resident if you like, and it has a first class user interface. If this package can't organize your days it's probably time to retire to Tahiti.

START is an elegant way to start frequently used Windows applications. It's completely user configurable. Requires Microsoft Windows.

KWIKTAX is a beautifully executed 1989 Canadian income tax spreadsheet. It lets you work out your taxes as well as including features to let you try "what-if" calculations. If you're going to cheat, do it electronically. Requires the AsEasy spreadsheet package, included with this collection. Also runs under Lotus 1-2-3.

GENE is a genealogical program to help you trace your family tree. It goes back further than most people have relatives and includes fields for all sorts of interesting information about your antecedents.

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Having a library of clip art on tap is tricky unless you own a scanner and a suitable source of paper clip art to start with. Almost Free Clip Art solves all this. Each one of our disks contains almost five hundred kilobytes of clip art – at least a dozen images per disk. These collections have been carefully chosen to each contain a variety of interesting pictures suitable for a wide range of applications.

These pictures are suitable for use with virtually all applications which accept bitmapped art. This includes Ventura Publisher, Aldus PageMaker, Word Perfect 5 and PC Paintbrush. The files are all provided in MacPaint format. The collections come with a utility to convert them to GEM/IMG, PC Paintbrush PCX and TIFF files.

More ☞

All of these pictures are in the public domain. You can use them without any copyright restrictions. At three hundred dots per inch they make first class spot illustrations of about two by three inches. They can, of course, be used at any resolution you like.

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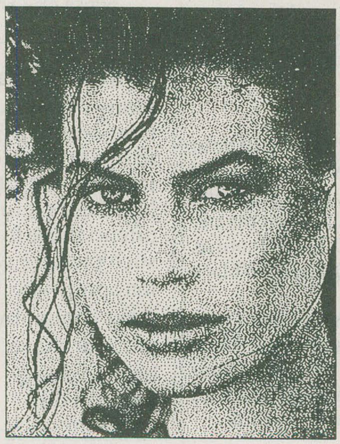
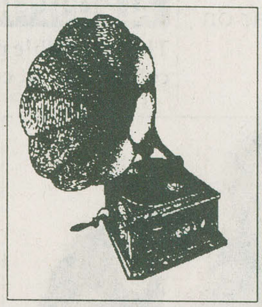


The illustrations in this sneak preview have all been drawn from the clip art disks described herein. Several of them, such as the portrait on the first page, are colour clip art dithered to black and white for reproduction.

ALMOST FREE COLOUR CLIP ART

Since we introduced these disks over a year ago, they've been immensely popular. Consisting of over two megabytes per collection of scanned full colour photographs and art, these pictures can be displayed on an EGA or... preferably... a VGA card. The results are luminous and fascinating, pictures which seem to leap from your monitor.



Many of the images in these collections have resoltions of 640 by 480 pixels or better in 256 colours. They have to be seen to be fully appreciated. They can be displayed on any EGA or VGA card with the viewer program provided. You might also want to get out GIF Users Toolkit, which includes a more sophisticated viewer and utilities which will allow you to convert this pictures for use as desktop publishing clip art.

COLOUR CLIP ART VOLUME 6

HUMMINGBIRD
A surrealistic hummingbird near some existential flowers.

MARGIE
A girl in a windstorm with unusual makeup.

MBDUFFEK
Woman reclining.

ASTRONAUT
An astronaut floating above the earth.

SILK
One wonders if silkworms really know what they're up to.

PIGS
Bacon on the hoof, Pink Floyd grounded.

PAULINA
Head and shoulders... mostly.

ALISON
Probably not her real name.

MOLISA
A woman of the future, the girl to excite your computer.

VGADNA
Part of the double helix.

APPLE
A hand painted apple.

RUBENS1
A painting... light, shadow and other artistic stuff.

FANTASIA
Mickey Mouse and some special effects.

RUBENS3
More light and shadow.

BEAUTY
Conceptual art.

WALRUS
A walrus on a rock, singing.

THINKING
A woman with something on her mind.

GILDA2
Probably also not her real name.

HENGE
Stonehenge at dawn, just before the tourists get there.

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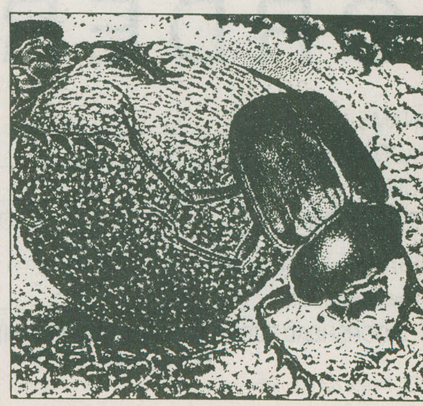

COLOUR CLIP ART VOLUME 7

IRELAND

Or a very small part of it.

BARTON

A landscape... motel art come to life.

TORNJNS

The effects of excessive wear on Levis.

EXCALID

A woman and her motorcar.

LEOPARD

A big cat.

OCEAN

After bathing at Baxters...

HELMET

Two of them, actually, along with some aircraft.

BICYCLE

Woman on bicycle.

AWAKE

Looks like about one in the afternoon.

LENSMIRR

A stunning bit of ray tracing.

TIGER1

Another large cat.

BRANDI

Almost certainly not her name.

PILLOW

A girl and her pillow.

LUNA

The moon as seen from somewhere closer than here.

CLOWN

A fellow with a large nose and excessive makeup.

ORDER DISK AFGIF7–SEE ORDER FORM

ALMOST FREE GIF USERS KIT

The incredible popularity of our GIF file colour clip art collections has prompted us to assemble this toolkit of programs for people who buy our GIF disks. It contains more and better programs than we've been able to include on the GIF disks themselves due to space constraints.

If you've bought one of our GIF collections, please check out this disk. It will make your GIF files a lot more interesting and quite likely a lot more useful as well.

This collection comes on two dual density floppies. It also includes several sample GIF files.

GRAFCAT Prints up a visual catalog of your image files to either a PostScript or LaserJet Plus compatible laser printer. Each page will contain sixteen images. GRAFCAT accepts any mixture of IMG, MacPaint, PCX and, of course, GIF files. The GIF images are dithered to black and white for easier viewing.

VGACAD is a public domain GIF paint program. It allows you to edit and even create your own two hundred and fifty-six colour GIF files. This is a first class package, and a lot of fun. Requires a mouse and a VGA card.

CSHOW is the best GIF file viewer yet written, and this is the latest version of this powerful package. It features panning over large files, a directory selection menu, loadable support for super VGA modes, colour palette adjustment and all the bells and whistles you could ask for. Note that this is a much more advanced version of CSHOW than was included with our early GIF collections.

GIFTOPCX and **PCXTOGIF** will convert between GIF and PCX file formats, allowing you to edit your GIF files with PC Paintbrush, as well as importing them into applications which support the PCX format. These packages support both conventional PCX files and the news two hundred and fifty-six colour PCX version four format.

POSTGIF allows you to create encapsulated PostScript files from full colour GIF files. These EPS files produce halftoned black and white images when printed. You can optionally include an EPS preview file, making this utility a perfect way of generating screen graphics for importation into desktop publishing packages such as Ventura. Requires a PostScript printer for output.

GIFPUB will dither GIF files down to black and white PCX files, suitable for use with desktop publishing software such as Ventura. The results are extremely good, and dithered art can preserve an amazing amount of the original GIF files it came from.

GIFWP converts GIF files into Word Perfect compatible graphics files.

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Note to Clip Art Users

Many of our clip art collections contain some images which are erotic or sexually oriented. While we know that the majority of our customers like these pictures, we do not wish to offend those for whom such pictures would be inappropriate. Those disks containing erotic art have been so designated in this sneak preview.

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Nickel Cadmium Care

Simple modifications to an inexpensive commercial NiCd charger will ensure long life for your batteries.

IAN HICKMAN

Battery powered equipment offers the great convenience of go-anywhere portability — at a price, batteries being much more expensive than the same energy from AC. I use the word battery loosely, in the modern sense, to mean either a battery or a single cell.

Strictly, a battery (of cells) is an arrangement of two or more cells connected in series so as to provide a higher voltage, such as a 9V zinc-carbon (6 cell) battery used in a portable radio.

Secondary Batteries

Compared with primary (use and throw away) batteries such as zinc-carbon, zinc chloride, alkaline manganese, lithium or oxide types, secondary (rechargeable) batteries can save their cost many times over. However, in practise the hoped-for economies sometimes do not materialize.

To digress for a moment, it's interesting to note that the term "NiCad" is a trademark owned by SAFT America of Georgia. The original patent was filed in 1961 by Gould, Inc., and sold to SAFT in 1982. Therefore, we'll use the spelling "NiCd" throughout.

You may find that the NiCd cells powering a Walkman type personal stereo player, for example, seem to last no time at all before needing recharging, so it's less trouble to revert to ordinary primary cells. In such a case, the problem often lies not with the cells but with their maintenance and conditions of use.

A professional NiCd battery pack, as used with a military radio transceiver, for example, will have been assembled from individual cells chosen all to have exactly the same amp-hour capacity, so that in use they all become discharged at the same time. Likewise, when recharged they will all have become fully charged at the end of the rated charge time. Consumer equipment, on the other hand, is often powered not from a NiCd battery as such, but rather a collection of NiCd cells which, even if all bought at the same time, have only nominally the same capacity.

Worse still, a typical NiCd battery charger cannot be relied upon to deliver exactly the same number of ampere-hours of charge to each and every cell when they are recharged. The result is that the weakest cell may become discharged before the others and then be subject to reverse charging from the remaining cells. If, furthermore, it receives less recharging than the others, it may become discharged progressively sooner on each charge-discharge cycle.

The exception is the true battery, such as the NiCd 9V (actually 8.4 volts), where of course the cells are permanently connected in series inside the battery. (This battery, usually of mass plate construction and therefore not suitable for fast charging, actually contains seven cells, since a NiCd cell only produces 1.2V, unlike a zinc-carbon cell.)

Use and Maintenance

Careful use and maintenance can prevent the problem of early exhaustion of one cell. If you have a lab bench stabilized power supply with a continuously adjustable current limit, this can be used to charge all NiCd cells in a piece of equipment in series, thus guaranteeing that they all receive the same total charge. It is often not even necessary to remove them from the radio/cassette or whatever.

Just remove the battery cover and poke the bared end of the positive lead down between the positive battery contact and the battery, and similarly for the negative lead. Set the power supply current limit to minimum and the output voltage to maximum. Switch the supply on and

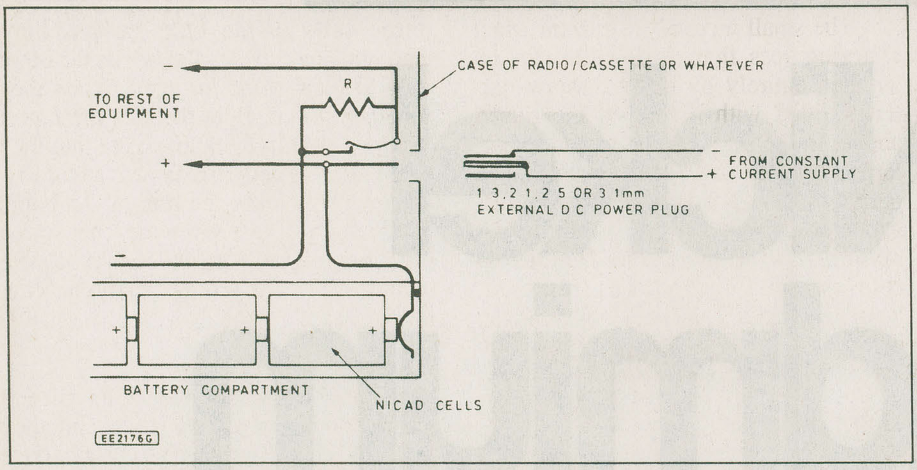

Fig. 1. Charging cells in the equipment. Centre pole positive is shown; check the polarity on the unit.

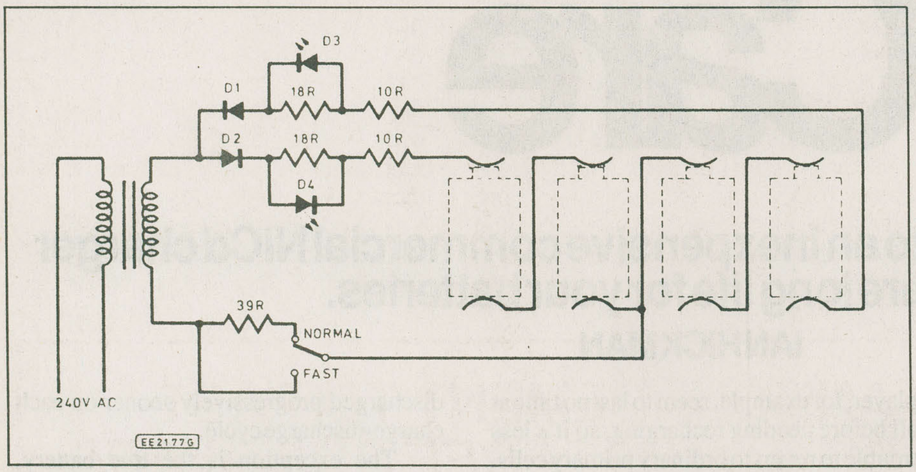

Fig. 2. Circuit of the commercial charger.

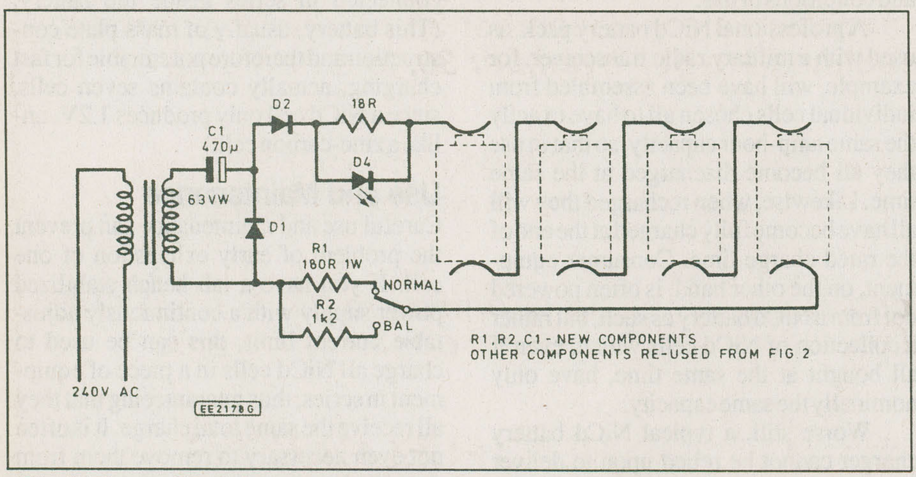

Fig. 3. The modified charger circuit.

advance the current limit control to the recommended charging current, e.g. 45mA for AA size cells.

If you never run the equipment from an external DC supply then an even more convenient scheme is possible. Just rewire the external DC input socket so that inserting the plug does not disconnect the battery. Now, the current limited supply can be simply injected via the socket. A wise precaution is to include a resistor, to limit the charging current to a safe value in the This can simply be wired across the socket's break-contact, which is designed to disconnect the equipment from the internal battery when an external power plug is inserted, see Fig. 1. For a medium sized radio/cassette using 6 C cells, a 22 ohm 1/2 watt resistor is suitable.

Simple Charger

I recently purchased, a mains operated NiCd battery charger designed to charge two or four AA cells; Fig 2 shows the circuit diagram of the charger as purchased and, as you can see, it offers a choice of standard or fast charge rates. The circuit is entirely typical of various makes of charger from the far east.

Two of the cells are charged on one half cycle of the mains and the other two on the alternate half cycle. The charging current is thus discontinuous or dirty DC, which is actually reckoned to be better for the purpose than smooth DC. It also explains how the LEDs light — 50mA of smooth DC would not produce the necessary 1.8V (or thereabouts) voltage drop across 18 ohms.

On normal charge, the 39 ohm resistor and the total transformer winding resistance referred to the secondary are common to both charging circuits. Assuming the voltage drops across the rectifier diodes, the 10 ohm resistors and the LEDs are equal, then the charging current will be equal — assuming the voltage drops across the cells in each circuit are also equal.

The charging current on normal proved to be about 63mA in each circuit, distinctly above the recommended value of 45 or 50mA, depending on the make of NiCd AA cell. On fast charge, the current was over 150mA and, without the equalizing effect of the 39 ohm resistor common to both charging circuits, the balance was poorer — all resistors were 5% tolerance.

Note that fast charge **should only be used** if you are certain that ALL the cells are FULLY discharged, and the recommended charging time **should NEVER be exceeded**, as overcharging at the fast rate is even more damaging to cells than overcharging at normal rate.

Modified Charger

Unfortunately my personal radio/stereo cassette uses three AA cells, which left me with a problem. Two of the cells could be charged in one circuit, and the third cell in the other, using a dummy

battery to complete the circuit. However, the charging currents would not be identical, due to the drop across two cells in one circuit against only one in the other.

I considered charging the dummy battery from a straight-through connection, to two silicon diodes in series, to simulate the volt drop across a NiCd, but exact equality of the charging current could still not have been guaranteed. The only way to ensure this is to charge all the cells, be it two, three or four, in series. It was therefore decided to modify the charger circuit.

The circuit of the modified charger is shown in Fig. 3. If all the cells are to be charged from the same current, then a higher back voltage must be overcome and a higher charging voltage is necessary. This was obtained from the same transformer by using a half wave voltage doubler circuit, involving the addition of C1. No smoothing capacitor was used, giving a dirty DC charging current as before. For safety, a generously rated 63V electrolytic was used. R1 was chosen to give a charging current of 45mA with four cells on charge, the current being slightly higher with three or two, but not excessive even with one.

The small increase in current when charging less than four cells can be avoided entirely by using dummy batteries fitted with diodes as mentioned above. In the interest of kindness to batteries, the fast charge facility was dropped entirely — this also ensured that the transformer was running well within its VA rating in the modified circuit. The alternative switch position was retained, however, and redesignated BAL, with an additional 1k2 series resistor. The reason for this will appear in a moment.

Discharge

Another very useful gadget was invented to assist in maintaining my NiCd cells in good condition. It consists of a battery holder designed to accept four D cells side by side, modified so that each cell position has a 1.25V 0.25A flashlight bulb (of the integral lens variety used in miniature flashlights) wired in parallel.

In addition to D cells, the holder will also accept C and AA cells, with the aid of some packing pieces, consisting of one inch lengths of wooden lath wrapped in foil. When the set of NiCds ceased to operate my personal stereo, I tried the three cells in the bulb gadget. Sure enough, one cell was flat, while the other two lit their bulbs for ages. When they finally expired, I put them in the Fig. 3 charger, safe in the knowledge that they were all in exactly the same state of discharge. Following the normal 14 hours charge they operated the personal stereo for much longer than previously, and have continued to do so through many charging cycles.

Overcharging

Overcharging NiCds, even at the normal charge rate is not recommended, but they will withstand overcharging at a lower rate — say 20 percent of the normal rate or 10mA for AA cells — without coming to any harm. So every so often, following a normal charge, I switch to the Bal (balance) position and leave the cells on charge for another 12 hours. This balancing charge ensures that even if one of the cells is a bit on the low side, it finally reaches the fully charged state, ready for the next discharge cycle.

Given this sort of care, your NiCds will last and last, giving you the 500-plus charging cycles promised by the manufacturer.

FEATURE

Interfacing a Microsoft Mouse to Turbo C

Learn the technique of writing a device driver.

DOUG BEDROSIAN

Most commercial software available today for an IBM PC or compatible allows for some form of interaction with a mouse. But for a novice programmer this feature might seem to advanced. Well this is just not the case, interfacing a mouse to your program is easy and clean to perform. This article will give you the knowledge and confidence you need to achieve this interaction, so read on.

The communication between the mouse and computer is mostly transparent to the user. Other than loading the mouse driver and seeing the effects of the mouse on an application program the user is unaware of the computer) mouse interaction.

There are generally two types of mouse drivers. The first type is considered a device driver, and must be loaded through the use of the config.sys file (eg: device=mouse.sys). The second type is a terminate and stay resident (TSR) program which can be loaded at any time. The two drivers perform the same tasks; the difference is in how they are loaded.

Once the driver is loaded it maps itself into interrupt 33h (hex). Therefore any time a program generates an interrupt

FUNCTION	INPUT	OUTPUT
Function 0 Reset and Status	M1=0	M1=status M2=no. buttons 0=no mouse
Function 1 Show cursor	M1=1	—
Function 2 Hide cursor	M1=2	
Function 3 Button status, position	M1=3	M2=Button Status M3=horiz. position M4=vert. position
Function 4 Set cursor position	M1=4 M3=new horiz. position M4=new vert. position	
Function 7 Set horiz. range	M1=7 M3=min. hor. position M4=max. hor. position	—
Function 8 Set vertical range	M1=8 M3=min. vert. position M4=max. vert position	
Function 15 Set Mickey/pixel ratio	M1=15 M3=hor. ratio	

Note: M1 = AX M2 = BX M3 = CX M4 = DX

33h the mouse routine will execute. The mouse routine uses the general purpose registers (ax,bx,cx,dx) for passing information to and from the calling program. Although some of the advanced features use other registers. Any programming language that has the ability to generate interrupts and interact directly with the general purpose registers can be used in a clean fashion to interface to the mouse. These criterium can be found in most high level languages for the PC, ranging from Fortran to C.

The process for making a call to the mouse is as follows:

1. Load the registers with the desired data.

2. Generate an interrupt 33h.

3. Read the return information from the registers.

That is all there is to communicating with the mouse.

We will now examine some of the most commonly used mouse functions. For a summary of these functions refer to table 1.

Function 0. Mouse Reset and Status. This function is always the first called when interfacing with the mouse. It checks for the presence of a mouse, if one is found it resets all mouse conditions, otherwise an error flag is set. Note: the reset condition for the cursor flag is off, therefore the show cursor (**Function 1.** function must be called before the cursor will appear.

Function 1. Show Cursor. The sole purpose of this function is to turn the cursor on.

Function 2. Hide Cursor. Likewise this function is only used for turning the cursor off.

Function 3. Get Button Status and Mouse Position. As the name implies this function is used for getting information back from the mouse. The button status is returned in a single parameter for both buttons. Bit 0 represents the left button while bit 1 is the right. A "1" implies that the button is currently pressed, while "0" implies the button is up.

The horizontal and vertical positions are returned in separate parameters. Note: in graphics modes 4, 5, and 6 the horizontal value returned is from 0 to 639. Modes 4, and 5 have screen coordinates from 0 to 319, therefore the parameters returned in these modes are even numbers only. Thus the horizontal value returned in modes 4,

LISTING 1.

```
/* A program to demonstrate the use of
 the Microsoft mouse with Turbo C.
 Compiled with Turbo C Version 2.0.
 Copyright (C) Doug Bedrosian 1989.
 Version 1.0 */

#include <stdio.h>  /*standard input and output*/
#include <dos.h>    /*used for making 8088 calls*/
#include <graphics.h> /*used for graphic functions*/
#include <mouse.h>  /*used for the mouse*/

/*function declarations*/
void mouse(int*,int*,int*,int*);
void initialize(); void screen_setup();
void draw(); void clear(int,int,int,int);

/*==========*/

main(argc,argv)
int argc;
char *argv[];
{
int m_pram_1=0,m_pram_2=0,m_pram_3=0,m_pram_4=0;

initialize();
if(argc>=3) { /*check for command line arguments*/
 m_pram_3=atoi(argv[1]); m_pram_4=atoi(argv[2]);
 m_pram_1=SET_MOTION; /*set new sensitivity*/
 mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
 }
screen_setup();
draw();
closegraph();
}

/*==========*/

/*----------*/

/*this function is used for making mouse calls
 *m_pram_n - parameters to send to the mouse
 * also used for returning information*/

void mouse(m_pram_1,m_pram_2,m_pram_3,m_pram_4)
int *m_pram_1,*m_pram_2,*m_pram_3,*m_pram_4;
{
union REGS in,out; /*in and out are used for
 sending and receiving from the 8088 registers*/
/*set up the registers*/
in.x.ax=*m_pram_1; in.x.bx=*m_pram_2;
in.x.cx=*m_pram_3; in.x.dx=*m_pram_4;
/*make a call to the mouse*/
int86(MOUSE,&in,&out);
/*set up the parameters*/
*m_pram_1=out.x.ax; *m_pram_2=out.x.bx;
*m_pram_3=out.x.cx; *m_pram_4=out.x.dx;
}

/*----------*/
```

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Intended to carry on from Book 1, this book deals with practical applications beyond the parallel and serial interface. "Real world" interfacing such as sound and speech generators, temperature, optical sensors, and motor controls are discussed using practical circuit descriptions.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.85
This book sets out to show how Electronic Music can be made at home with the simplest and most inexpensive equipment.

BP74: ELECTRONIC MUSIC PROJECTS $10.00
R.A. Penfold
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuxx Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator, etc.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING $7.80
R.A. Penfold
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. This book will help the reader overcome these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES $5.85
This book is based on the author's own experience in learning BASIC and also in helping others, mostly beginners to programming, to understand the language.

BP234: TRANSISTOR SELECTOR GUIDE $15.00
Listings of British, European and eastern transistor characteristics make it easy to find replacements by part number or by specifications. Devices are also grouped by voltage, current, power, etc., includes surface-mount conversions.

BP233: ELECTRONIC HOBBYIST HANDBOOK $15.00
A single source of easily located information: colour codes, pinouts, basic circuits, symbols, etc.

BP101: HOW TO IDENTIFY UNMARKED IC's $1.95
An unusual and fascinating chart that is highly recommended to all those interested in electronics and which will hopefully pay for itself many times over, by enabling the rEader to use IC's that might otherwise have been scrapped.

BP121: HOW TO DESIGN AND MAKE YOUR OWN PCBs $5.85
The purpose of this book is to familiarize the reader with both simple and more sophisticated methods of producing printed circuit boards. The book emphasizes the practical aspects of printed circuit board designs and construction.

BP125: 25 SIMPLE AMATEUR BAND AERIALS $5.85
This book describes how to build 25 amateur band aerials. The designs start with the simple dipole and proceed to beam, triangle and even a mini-rhombic.

BP180: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS $9.00
Shows how home computers can easily be applied to the control of model railroads and other quite sophisticated control. A variety of projects are discussed as well as circuits for train position sensing, signal and electric points control, etc.

BP100: AN INTRODUCTION TO VIDEO $5.85
This book is for the person who has just, or is about to buy or rent video equipment but is"nt sure what it's all about.

BP78: PRACTICAL COMPUTER EXPERIMENTS *$5.25*
The aim of this book is to enable the reader to simply and inexpensively construct and examine the operation of a number of basic computer circuit elements and it is hoped gain a fuller understanding of how the mysterious computer "chip" works.

BP185: ELECTRONIC SYNTHESIZER CONSTRUCTION *$9.00*
With this book a relative beginner should be able to build, with a minimum of difficulty and at a reasonably low cost, a worthwhile monophonic synthesizer and also learn a great deal about electronic music synthesis in the process.

BP115: THE PRE-COMPUTER BOOK *$5.85*
Aimed at the absolute beginner with no knowledge of computing, this entirely non-technical discussion of computer bits and pieces and programming is written mainly for those who do not possess a microcomputer but either intend to one day own one or simply wish to know something about them.

BP92: ELECTRONICS SIMPLIFIED - CRYSTAL SET CONSTRUCTION *$5.25*
This is a book written especially for those who wish to participate in the intricacies of electronics.

BP72: A MICROPROCESSOR PRIMER *$5.25*
In an attempt to give painless approach to computing, this inexpensive book will start by designing a simple computer and then the short-comings of this simple machine will be discussed and the reader is shown how these can be overcome. Includes a glossary of microprocessor terms.

BP42: 50 SIMPLE L.E.D. CIRCUITS *$5.85*
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE *$9.00*
This book is designed to help the user find possible substitutes for a popular user-oriented selection of modern transistors and includes devices produced by over 100 manufacturers.

BP140: DIGITAL IC EQUIVALENTS AND PIN CONNECTIONS *$15.00*
Shows equivalents and pin connections of a popular user- oriented selection of Digital Integrated Circuits. Includes European, American and Japanese devices.

BP136: SIMPLE INDOOR AND WINDOW AERIALS *$7.00*
People living in apartments who would like to improve shortwave listening can benefit from these instructions on optimizing the indoor aerial.

BP156: AN INTRODUCTION TO QL MACHINE CODE *$10.00*
The powerful sinclair QL microcomputer has some outstanding capabilities in terms of its internal structure. With a 32-bit architecture, the QL has a large address range, advanced instructions which include multiplication and division.These features give the budding machine code programmer a good start at advanced programming methods. This book assumes no previous knowledge of either the 68008 or machine code programming.

BP59: SECOND BOOK OF CMOS IC PROJECTS *$7.80*
This book carries on from its predecessor and provides a further selection of useful circuits, mainly of a simple nature. The book is well within the capabilities of the beginner and more advanced constructor.

BP258 LEARNING TO PROGRAM IN C *$19.00*
This book is a guide to C programming. C statements are introduced and explained with the help of simple, but completely working programs.

BP141: LINEAR IC EQUIVALENTS AND PIN CONNECTIONS *$23.80*
Adrian Michaels
Find equivalents and cross-references for both popular and unusual integrated circuits. Shows details of functions, manufacturer, country of origin, pinouts, etc... includes National, Motorola, Fairchild, Harris, Intersil, Philips, ADC, AMD, SGS, Teledyne, and many others.

BP7: RADIO AND ELECTRONICS COLOUR CODE AND DATA CHART *$3.00*
Opens out to Wall Chart approximately 584 X 457mm. Includes many Radio & Electronics Colour Codes in use in UK, USA, Europe and Japan. Covers Resistors, Capacitors, Transformers, Field Coils, Fuses, Battery Leads, etc.

BP225: A PRACTICAL INTRODUCTION TO DIGITAL ICs *$7.00*
This book deals mainly with TTL type chips such as the 7400 series. Simple projects and a complete practical construction of a Logic Test Circuit Set are included as well as details for a more complicated Digital Counter Timer project.

BP147: AN INTRODUCTION TO 6502 MACHINE CODE *$10.00*
The popular 6502 microprocessor is used in many home computers; this is a guide to beginning assembly language.

BP88: HOW TO USE OP-AMPS *$11.80*
E.A. Parr
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F.A. Wilson, C.G.I.A., C.Eng.,
Although written for readers with no more than ordinary arithmetical skills, the use of mathematics is not avoided, and all the math required is taught as the reader progresses. Each book is a complete treatise of a particular branch of the subject and therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

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BP63: BOOK 2. This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity utilities.

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BP77: BOOK 4. A complete description of the internal workings of microprocessor.

BP89: BOOK 5. A book covering the whole communication scene.

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This book provides a number of practical designs for beginners and experienced project builders. These projects utilize a range of modern opto-electric devices, including such things as fibre optics, ultra-bright LEDs and passive IR detectors.

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F.G. Rayer, T. Eng., (CEI), Assoc.IERE.
Relays, bi-directional triodes (TRIACs), and silicon controlled rectifiers (SCRSs), have a wide range of applications in electronics today. This book gives practical working circuits which should present the minimum of difficulty for the enthusiast.. In most of the circuits there is a wide latitude in component values and types, allowing easy modification and adaptation.

BP84: DIGITAL IC PROJECTS *$7.80*
F.G. Rayer, T. Eng. (CEI), Assoc.IERE.
This book contains both simple and more advanced projects for the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams.

BP95: MODEL RAILWAY PROJECTS *$7.80*
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered included controllers, signals and sound effects: stripboard layouts are provided for each project.

BP144: FURTHER PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE *$15.00*
This book covers many aspects of electronics where a knowledge and familiarity of the appropriate formulae is essential for a fuller understanding of the subject. An essential addition to the library of all those interested in electronics.

BP44: IC 555 PROJECTS *$10.00*
E.A. Parr, B.Sx., C. Eng., M.I.EE.
Every so often a device appears that is so useful that one wonders how life went on before it. The 555 timer is such a device included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS *$7.80*
R.A. Penfold
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, and more.

BP49: POPULAR ELECTRONIC PROJECTS by R. A. Penfold *$10.00*
Includes a collection of the most popular types of circuits and projects which will provide a number of designs to interest most electronics constructors. The projects cover a wide range and are divided into four basic types. Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP99: MINI-MATRIX BOARD PROJECTS by R. A. Penfold *$7.60*
Twenty useful projects which can all be built on a 24 X 10 hole matrix board with copper strips. Includes Door-buzzer, Low-voltage Alarm, AM Radio, signal Generator, Projector Timer, Guitar Headphone Amp. and more.

BP103: MULTI-CIRCUIT BOARD PROJECTS by R.A. Penfold *$7.80*
This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 *$9.00*
R.A. Penfold
70 plus circuits based on modern components aimed at those with some experience.

BP127: HOW TO DESIGN ELECTRONIC PROJECTS *$9.00*
Although information on stand circuits blocks is available, there is less information on combining these circuit parts together. This title does just that. Practical examples are used and each is analysed to show what each does and how to apply this to other designs.

BP195: AN INTRODUCTION TO SATELLITE TELEVISION *$15.00*
For the absolute beginner or anyone thinking about purchasing a satellite TV system, the story is told as simply as such a complex one can be.

BP106: MODERN OP-AMP PROJECTS by R. A. Penfold *$7.80*
Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS - BOOK 1 *$9.00*
R.A. Penfold
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects in this book have been designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of components it is possible to build, in turn, every project shown.

BP122: AUDIO AMPLIFIER CONSTRUCTION *$6.75*
A wide circuits is given, from low noise microphone and tape head preamps to a 100W MOSFET type. There is also the circuit for 12V bridge amp giving 18W. Circuit board or strip-board layout are included. Most of the circuits are well within the capabilities of even those with limited experience.

BP179: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS *$12.00*
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge the gap.

BP108: INTERNATIONALDIODE EQUIVALENTS GUIDE *$7.00*
Cross-references European, American and Japanese diode part numbers. Besides rectifier diodes, it includes Zeners, LEDs, Diacs, Triacs, SCRs, OCIs, photodiodes, and display diodes.

BP118: PRACTICAL ELECTRONIC BUILDING BLOCKS — BOOK 2 *$7.60*
R.A. Penfold
This sequel to BP117 is written to help the reader create and experiment with his own circuits by combining standard type circuit building blocks. Circuits concerned with generating signals were covered in Book 1, this one deals with processing signals.

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and 5 must be divided by two in order to match the screen coordinates.

Function 4. Set Cursor Position. This function allows the cursor to be place at any horizontal, vertical position. **Function 7.** Set Minimum and Maximum Horizontal Position. This function allows the user to set the horizontal range that the mouse can travel.

Function 8. Set Minimum and Maximum Vertical Position. Likewise this function allows the user to set the vertical range the mouse can travel.

Function 15. Set Mickey/Pixel Ratio. This function allows the setting of the mouse sensitivity in the horizontal and vertical directions. Although not all mouse functions have been described, the ones which have should prove sufficient for most programmers. If you feel you would like more information about the mouse and its associated functions please refer to one of the texts listed at the end of this article.

There's no better way to comprehend the mouse functions then with an example. The example given is a CAD (Computer Aided Design) program with limited ability, thus the name given to the program is "Simple CAD". The program allows the user to draw on the screen with three different colours and also to erase any portion of the screen.

As mentioned the program can draw in any one of three colours, to do this, the user selects the desired colour by placing the cursor over the coloured bar and pressing the left mouse button. The "Active Colour" bar will now display the newly selected colour. To select the erase option place the cursor over the black bar and press the left mouse button, again the "Active Colour" bar will change.

To actually do some drawing or erasing move the cursor into the drawing window and press the left mouse button. The pen status should change to "DW" (down), now if you move the mouse, lines will be drawn in the "Active Colour". If the right mouse button is pressed the pen status will change to "UP", and no lines will be drawn when you move the mouse.

For a reference an "X" and "Y" coordinate system has been provided.

To exit the program move the cursor over "EXIT" and press the left mouse button.

Now that we know what the program is to do we will examine the source code function by function.

We will begin with the function "mouse(m_pram_1, m_pra,m_2,m_pram_3,m_pram_4)"

```
/*This function resets the mouse and sets
*the graphics mode, it also defines all
*conditions for the mouse        */

void initialize()
{
int m_pram_1=0,m_pram_2=0,m_pram_3=0,m_pram_4=0,
 error,graphdriver,graphmode;

/*reset the mouse, if no mouse present exit program*/
m_pram_1=RESET;
mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
if(m_pram_1==0) {/*if mouse not installed exit program*/
 printf("\n Microsoft Mouse Not Installed!!!!!");
 exit(1);
 }
/*initialize graphics mode, CGA 320 by 200*/
graphdriver=CGA; graphmode=CGAC0; /*palette 0*/
initgraph(&graphdriver,&graphmode,"");
error=graphresult(); /*check for a graphics error*/
if(error<0) {   /*and report the type   */
 printf("Graph Error %s! ",grapherrormsg(error));
 exit(1);
 }
/*set the horizontal and vertical range for the mouse*/
m_pram_1=SET_HORIZONTAL; /*set horizontal range*/
m_pram_3=2; m_pram_4=638;
mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
m_pram_1=SET_VERTICAL; /*set vertical range*/
m_pram_3=21; m_pram_4=197;
mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
m_pram_1=PLACE_CURSOR;/*place cursor at the center of*/
m_pram_3=305; m_pram_4=90;  /*the drawing area*/
mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
m_pram_1=CURSOR_ON;   /*turn the cursor on*/
mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
}

/*----------*/

/*this function sets up the screen format*/

void screen_setup()
{
setcolor(CGA_LIGHTRED);/*drawing colour*/
rectangle(0,0,319,199); /*draw boarders*/
line(0,20,319,20);line(279,20,279,199);
/*outlines for the drawing colours*/
line(279,35,319,35);line(279,50,319,50);
line(279,65,319,65);line(279,80,319,80);
line(279,114,319,114);line(279,129,319,129);
/*fill the boxes with drawing colours*/
setfillstyle(SOLID_FILL,CGA_LIGHTRED);
floodfill(280,21,CGA_LIGHTRED);
floodfill(280,115,CGA_LIGHTRED);
setfillstyle(SOLID_FILL,CGA_LIGHTGREEN);
floodfill(280,36,CGA_LIGHTRED);
setfillstyle(SOLID_FILL,CGA_YELLOW);
floodfill(280,51,CGA_LIGHTRED);
/*output text for the screen*/
```

The four parameters are equivalent to M1, M2, M3, and M4 of table 1. The function loads the general purpose registers using "in.x.nn = m_pram_y", were nn is the register and y is the parameter. Next a call is made to interrupt 33h. After the call to interrupt 33h the OOoutput parameters are loaded using "*m_pram_y = out.x.nn". The function is then terminated.

The next function to examine is "clear(x1,y1,x2,y2)". This function is used to clear a specified area on the screen. First the area to be cleared is set as the active view port ("setviewport(x1,y1,x2,y2)"), next the active view port is cleared ("clearviewport()"), and finally the active view port is returned to the full screen ("setviewport(0,0,319,199)").

The function "initialize()" is used to initialize the mouse and set up the graphics mode. To initialize the mouse, function 0 is called. If a "0" is returned in m_pram_1 then a mouse was not detected and the program will report the error and exit. Next the graphics mode is initialized. If any of the driver or font files are not found in the present directory the program will report the error and exit. The horizontal and vertical positions are set using functions 7 and 8. For "Simple CAD" the horizontal range is from 2 to 638 and the vertical range is from 21 to 197. The cursor is placed at the centre of the drawing window and then turned on. This is done by using functions 4 and 1. The initialize function is then terminated.

The next function to look at is "screen_setup()". This function is used for displaying the format of the screen. This function utilizes Turbo C's graphic functions. If these functions are unfamiliar to you please refer to one of the appropriate text's on Turbo C listed at the end of this article.

The function "draw()" is were the interaction of the mouse comes into play. The function gets information back from the mouse by using function 3 (button status and position). A check is made to see if the cursor is over the pick window and that the left button is pressed. If both of these conditions are true the following conditions are checked. 1) is the cursor over "EXIT", if so the while loop will be terminated. 2) is the cursor over any of the drawing colours, if so the "Active Colour" is cleared ("clear(280,115,318,128)"), and a check is made to see what colour the cursor is over. Next the new "Active Colour" is displayed and the variable

```
outtextxy(281,95,"ACTIVE");
outtextxy(281,104,"COLOUR");
outtextxy(281,141,"Y=");outtextxy(281,131,"X=");
outtextxy(281,151,"PEN=");outtextxy(286,185,"EXIT");
outtextxy(200,1,"VER. 1.0");
outtextxy(200,10,"BY DOUG BEDROSIAN");
settextstyle(TRIPLEX_FONT,HORIZ_DIR,1);
setcolor(CGA_YELLOW);outtextxy(49,1,"SIMPLECAD");
settextstyle(SMALL_FONT,HORIZ_DIR,4);
}

/*----------*/

/*this function allows the user to draw
 *and erase on the screen*/

void draw()
{
int m_pram_1=0,m_pram_2=0,m_pram_3=0,m_pram_4=0,
  oldx=0,oldy=0;
char go_on=1,pen=0,x[4],y[4],colour=CGA_LIGHTRED;

outtextxy(306,151,"UP"); /*display initial setting*/
while(go_on)
 {
 m_pram_1=GET_INFO; /*get present information*/
 mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
 /*is the mouse in the pick window*/
 if(((m_pram_3/2)>279)&&((m_pram_2&1)==1)){
  if((m_pram_4>185)&&(m_pram_4<195)) go_on=0; /*exit?*/
  if((m_pram_4>20)&&(m_pram_4<80)){/*over drawing colours*/
  clear(280,115,318,128);/*remove old drawing colour*/
 if((m_pram_4>20)&&(m_pram_4<=35)){/*red bar?*/
  colour=CGA_LIGHTRED;
  setfillstyle(SOLID_FILL,CGA_LIGHTRED);
  floodfill(281,116,CGA_LIGHTRED);
  }
 if((m_pram_4>35)&&(m_pram_4<=50)){/*green bar?*/
  colour=CGA_LIGHTGREEN;
  setfillstyle(SOLID_FILL,CGA_LIGHTGREEN);
  floodfill(281,116,CGA_LIGHTRED);
  }
 if((m_pram_4>50)&&(m_pram_4<=65)){/*yellow bar?*/
  colour=CGA_YELLOW;
  setfillstyle(SOLID_FILL,CGA_YELLOW);
  floodfill(281,116,CGA_LIGHTRED);
  }          /*black bar?*/
 if((m_pram_4>65)&&(m_pram_4<80)) colour=BLACK;
  }
  }
 else if((m_pram_3/2)<279){ /*in the drawing area?*/
  setcolor(CGA_YELLOW); /*set text colour*/
  if(m_pram_2>0){/*was one of the buttons pressed*/
  clear(305,150,318,161);/*remove old state*/
  if(m_pram_2&1) { outtextxy(306,151,"DW"); pen=1;}
  if(m_pram_2&2) { outtextxy(306,151,"UP"); pen=0;}
  } /*update coordinates if necessary*/
  if((m_pram_3!=oldx)||(m_pram_4!=oldy)){
  clear(295,130,318,150);/*remove old coordinates*/
  itoa((m_pram_3/2)-1,x,10); itoa(m_pram_4-21,y,10);
  outtextxy(296,131,x); outtextxy(296,141,y);
```

```
setcolor(colour);
if(pen==1){ /*is the pen down*/
 m_pram_1=CURSOR_OFF; /*remove cursor*/
 mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
 /*draw line*/
 line(oldx/2,oldy,m_pram_3/2,m_pram_4);
 m_pram_1=CURSOR_ON; /*restore cursor*/
 mouse(&m_pram_1,&m_pram_2,&m_pram_3,&m_pram_4);
 }
oldx=m_pram_3; oldy=m_pram_4; /*save present location*/
 }
 }
 }
}

/*----------*/

/*this function clears a set area*/

void clear(x1,y1,x2,y2)
int x1,x2,y1,y2;
{
setviewport(x1,y1,x2,y2,1); /*set area to clear*/
clearviewport();      /*clear the set area*/
setviewport(0,0,319,199,1); /*set area to full screen*/
}
/*----------*/
```

"colour" is set accordingly. If the cursor is not over the pick window but in the drawing window the following conditions are checked. 1) is one of the buttons pressed, if so the pen status is cleared ("clear(305,150,318,161)"), and a check is made to determine which button was pressed. The pen status and variable "pen" are updated accordingly. 2) has the cursor position changed since the last check. If so the following is done. a) the old coordinates are cleared ("clear(295,130,318,150)"). The cursor position parameters are converted to strings and then displayed on the screen. b) if the pen status is "DW" ("pen"=1) then the cursor is turned off (function 2), a line is drawn from the last cursor position to the present position, and the cursor is then turned on again (function 1). c) the last step is to save the present location of the cursor. The function is then terminated.

It is necessary to turn the cursor off if you are going to draw to an area that the cursor presently occupies. This is necessary because the cursor and image you want to draw will occupy the same video memory, and the process by which the mouse works will end up erasing any portion of what was drawn that occupied the same area on the screen as the cursor did.

The last function to examine is "main(argc,argv)". This is the function that begins execution. Two parameters can be passed to "main" from the DOS command line. The first is the horizontal sensitivity and the second is the vertical sensitivity. If the two parameters are included when the program is executed the function will set the sensitivity of the mouse to these new values (using function 15). At the end of "main" the function "closegraph()" is called. This is used to shut down the graphics mode and restore the system to its original screen mode.

In keeping with the "C" style a header file called "mouse.h" has been included. The file contains all mouse definitions necessary for "Simple CAD".

Now a few words about Turbo C. If you are going to use the integrated environment as apposed to the command line version you will have to create a project file. The file should look as follows.

graphics.lib
source code filename.c

The project file should have the extension ".prj". The project file is loaded by selecting the "Project" option in Turbo C. It is necessary to use a project file containing "graphics.lib" because Turbo C does not included "graphics.lib" when it links, therefore any calls to graphic functions will result in a linker error if this is not done.

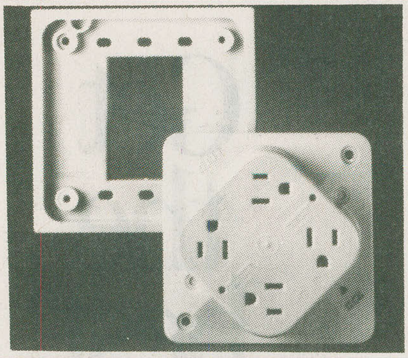
When you load the program it is necessary to have the following files in the current directory.

cga.bgi
litt.chr
trip.chr

These are necessary because the executable file reads these files to set up the graphics mode and to use the different fonts. It is possible to include the necessary information from these files in your executable file. Refer to Appendix D of the Turbo C Reference Manual on how to do this.

The information presented should allow most programmers to comfortably interface to a mouse.

 Continued from page 7



Surge Arrestor

A new surge arrestor that fits into existing electrical outlet boxes has been introduced by Bryant Electric, a division of Westinghouse Canada. The Quadplex Surge offers surge protection of up to 3,000 amps at 530 volts. The four outlets are rotated at 90 degrees to prevent blocking by electrical cords. Current capacity is 15 amps for the CSA-listed model and the ground pin can be isolated from the power ground for sensitive electronics. They're at Wesco locations across Canada, or contact Westinghouse Canada Inc., PO Box 2510, Hamilton, Ontario L8N 3K2, (416) 528-8811.

Circle No. 8 on Reader Service Card

Tiny Voice Synth

Texas Instruments has made a massive mailing (over 200,000) of a credit-card sized voice synthesizer chip and speaker, including the talking device in ads in a special Business Week edition in late '89 as well as press releases. When an adhesive tab is removed, the device speaks a 15 second, 42-word text with great clarity and inflection—none of that does-not-compute monotone. Three tiny batteries, a few passive components and a one-inch piezo speaker support the TSP50C10 speech synthesis chip.

Cost of the chip itself is under $2 (US) in very large quantities, and the complete unit as mailed was about $4 (US). TI feels that this price breakthrough will allow high-quality speech synthesis in consumer products that retail for "as little as $10". Soon we'll be able to figure out what those Chatty Cathy dolls are actually saying. Texas Instruments, Semiconductor Group, PO Box 809066, Dallas, Texas 75380-9066.

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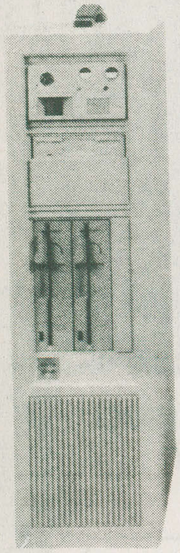

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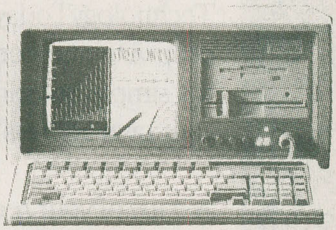

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The Techie's Guide to C Part 13

This month we're going to look at the very useful facility of reading the disk directory from a C language program.

STEVE RIMMER

Aside from providing you with a command line to type on and some basic utility programs, DOS has a lot of features which you'll only encounter at the programming level. It provides a myriad of "services" which are available to programs to make them easier to write. These range from simple things like printing a character to the screen right on through disk management and some local area network functions.

As DOS is, in fact, a disk operating system, it's not surprising that a lot of its services have to do with disks. These fall nicely into file management facilities, such as those we've been tapping into over the past few months, and directory management facilities. The latter group can be especially useful and kind of interesting if you're writing programs which work with files.

DOS... and hence C... provide you with tools to allow you to see what files are on your disk. These tools can also be used to check out whether a specific file is there. As DOS treats many different, and apparently unrelated, disk phenomena as files, these same tools will also allow you to locate things like subdirectories and the volume name of a disk.

This month we're going to see how these tools actually work.

First and Next

There are two functions under Turbo C which deal with reading a disk directory, called *findfirst* and *findnext*. Used together, these functions allow you to step through all the files in a directory which match a wild card specification.

Let's see what these functions do before we get into exactly how they do it. We'll search for all the C program files in the current directory, that is, "*.C".

We would begin by passing "*.C" to *findfirst*. Assuming that there was at least one file that matched this specification, it would place the file name in an as yet undiscussed data structure and return zero. We would the pass the aforementioned data structure to *findnext*. If it found a second file which matched the specification, it too would return zero and place the name of the second file in the data structure. We would continue to call *findnext* until it did not return zero, at which time we could assume that all the matching files had been found.

The data structure in question is called an *ffblk*. It looks like this.

```
structffblk{
char ff_reserved[21];
char ff_attrib;
unsigned ff_ftime;
unsigned ff_fdate;
long ff_fsize;
char ff_name[13];
};
```

This is everything which can be known about a file from its directory entry.

The first field, *ff_reserved*, is fairly meaningless for our purposes... it's used by DOS to communicate between *findfirst* and subsequent calls to *findnext*. The *ff_attrib* field is the file attribute of the directory entry which is found, something we'll discuss later on. The *ff_ftime* and *ff_fdate* fields are the file time and date of creation, the same ones you see in a DOS DIR listing. The *ff_fsize* field is the number of bytes in the file. Finally, *ff_name* is a C style string which holds the file's name.

The proper form of *findfirst* is like this.

```
struct ffblk f
int n;

n=findfirst(path,&n,0);
```

In this case, *path* is a string which holds a file specification. It can include a path component... you could pass "C:\TC*.C", for example, or more correctly "C:\\TC*.C", as the C precompiler gobbles up individual backslashes. The path can be in upper or lower case.

The third argument is the file attribute. We'll leave this as zero for the time being.

The value in *n* will be zero if *findfirst* found a file that matched the file specification.

You'd use *findnext* like this.

```
n=findnext(&f);
```

This assumes that *f* has been through *findfirst* at least once.

The following bit of code will print a listing of every file in your current directory.

```
dir()
{
struct ffblk f;
int n;

n=findfirst("*.*",&f,0);
if(n==0){
do{
puts(f.ff_name);
n=findnext(&f);
}while(n==0);
}
}
```

This is actually a bit more involved that it needs to be. There's a rather more elegant... if somewhat more obtuse... structure for doing the same thing.

```
dir()
{
struct ffblk f;
int n;

for(n=findfirst("*.*",&f,0);!n;n=findnext(&
f))
puts(f.ff_name);

}
```

If you understand how a *for* statement works under C, you'll have no trouble figuring out what this does.

Practical Directory

Let's digress for a moment and look at some practical considerations in using this facility. We're going to write a simple sorted directory program.

In this program, we'll allocate a buffer big enough to hold a reasonable number for file names... a thousand should do... and then load the *ffblk* structs returned by *findfirst* and *findnext* into the buffer in the order they're found. We'll then use the Turbo C *qsort* function to sort them into alphabetical order. The *qsort* function is a fairly complex bit of work... we'll leave its complete discussion for another time.

Having sorted the names into alphabetical order, they can be displayed on the screen. There are four potentially useful bits of information associated with each file entry, these being the file name itself, its size in bytes, its time of creation and its date of creation.

The time and date of creation of a file are formatted in a particularly obtuse way. Their various component parts are stored as bits in an unsigned integer. You can see how this works if you regard an integer as being sixteen bits.

The time is formatted line this

Bits 0 through 4 two second blocks
Bits 5 through 10 minutes
Bits 11 through 15 hours

We'll ignore the minutes field in this example. If we wanted to know the minutes portion of the file creation time, we would do this.

```
minutes=(n f.ff_fdate & 0x07e0)>>5;
```

The number being ANDed with the date value is a mask which selects the appropriate bits. If you consider that an integer is sixteen bits, this would be the binary representation of a number having all the bits from five through ten selected.

0000011111100000

This number in hex would be 0x07e0.

We must shift the result of the AND right by five bits to wind up with a proper integer value.

This is the format of the date.

Bits 0 through 4 day of the month
Bits 5 through 8 month
Bits 9 through 15 year past 1980

The month value runs from one through twelve. As such, if we store the month names in an array, this value minus one serves as the index into this array.

Here, then, in the program. This version of it is designed for use with a colour monitor. If you have a black and white tube, change the four colour defines at the top of the program to reflect this. For example,

```
#define name_atr LIGHTCYAN+(RED
<<4)
```

would become

```
#define name_atr WHITE
```

If you do have a colour monitor and you want to alter the colours I've chosen, note that there are two colours for each attribute. The leftmost one is the foreground colour. The rightmost one, red in this case, is the background colour. Screen text colours and how they work will be discussed in a future installment of this series.

```
/*
Sorted directory program
Copyright (c) 1989 Alchemy Mindworks

The source code for the current version of
this
program is available on a 5 1/4 inch floppy
disk
for $10.00 from Alchemy Mindworks Inc.,
P.O. Box
313, Markham, Ontario L3P 3J8.

"Perhaps we could tax sex... this would
allow us to tax not only the act but the
tax as well."
Attributed to a
highly placed Mulroney aid
*/
#include "stdio.h"
#include "dir.h"
#include "alloc.h"
#include "conio.h"

#define maxfile 1024
#define dirsize (sizeof(struct ffblk))

/* text attributes for the directory listing */
#define name_atr LIGHTCYAN+(RED
<<4)
#define size_atr CYAN+(RED<<4)
#define time_atr LIGHTBLUE+(RED
<<4)
#define date_atr BLUE+(RED<<4)

char *filetime(),*filedate();
char *buffer;
int count=0;

main(argc,argv)
int argc;
char *argv[];
{
char filespec[129];

if(argc>1) strcpy(filespec,argv[1]);
else strcpy(filespec,"*.*");

if((buffer=malloc(maxfile*dirsize))!=
NULL){
```

Techie's Guide to C Programming, Part 13

```
get_dir(filespec);
if(count){
sort_dir();
show_dir();
    } else puts("File not found");
free(buffer);
textattr(WHITE);
clrscr();
} else puts("Error allocating memory");
}

get_dir(s) /* load the buffer with the direc-
tory */
char *s;
{
struct ffblk f;
int n;

for(n=findfirst(s,&f,0);!n;n=findnext(&f))
{
if(f.ff_attrib != 0x10)
memcpy(buffer+(dirsize*count++),
(char *)&f,dirsize);
if(count>=maxfile) break;
}
}

sort_dir() /* sort the directory by file name
*/
{
int dircheck();

qsort(buffer,count,sizeof(struct ffblk),dir-
check);
}

dircheck(e1,e2)  /* compare two files */
char *e1,*e2;
{
struct ffblk *p1,*p2;

p1=(struct ffblk *)e1;
p2=(struct ffblk *)e2;
return(strcmp(p1->ff_name,p2-
>ff_name));
}

show_dir() /* display the directory */
{
struct ffblk f;
char b[30];
int i,n;

for(i=0;i<count;++i){
if(!(i % 50)){
n=0;
gotoxy(1,25);
if(i) getch();
textattr(name_atr);
clrscr();
}
if(n>24) gotoxy(41,n-24);
else gotoxy(1,1+n);
memcpy((char *)&f,
buffer+(dirsize*i),
dirsize);
textattr(name_atr);
cprintf(" %-12.12s",f.ff_name);
textattr(size_atr);
cprintf(" %7lu",f.ff_fsize);

textattr(time_atr);
cprintf(" %-6.6s",filetime(f.ff_ftime));

textattr(date_atr);
cprintf(" %s",filedate(f.ff_fdate));
++n;
}
gotoxy(1,25);
getch();
}

char *filedate(l) /* format a file date */
unsigned int l;
{
static char s[20];
static char m[12][4]={
"Jan","Feb","Mar",
"Apr","May","Jun",
"Jul","Aug","Sep",
"Oct","Nov","Dec"};
unsigned int day,month,year;

day=(l & 0x001f);
month=(l & 0x01e0)>>5;
year=(l & 0xfe00)>>9;

sprintf(s,"%s %u,%u",m[month-
1],day,year+1980);
return(s);
}

char *filetime(l) /* format a file time */
unsigned int l;
{
static char s[10];
unsigned int min,hrs;

min=(l & 0x07e0)>>5;
hrs=(l & 0xf800)>>11;

    if(hrs < 13)
sprintf(s,"%u:%02.2ua",hrs,min);
    else sprintf(s,"%u:%02.2up",hrs-
12,min);
    return(s);
    }
```

If you call this program SDIR.C and type it into Turbo C or get it on a floppy disk, you can compile it to SDIR.EXE or SDIR.COM. If you type SDIR all by itself, you will see all the files in the current directory one page at a time. If you type SDIR *.C, for example, you'll see all the .C files.

This is a very interesting program to experiment with, and there are all sorts of things you can add to it. Next month, we'll talk about some of the other ways to use the directory search facilities, which might give you some ideas for making this program do additional things.

FEATURE

PC Hardware Interfacing Part 13

This month we'll look at a working version of the serial port driver code.

STEVE RIMMER

Over the past few installments of this series we've discussed the development of assembly language routines to deal with the serial port card in a practical way. This has involved the use of interrupts, which are nasty but largely essential. It has also involved the use of some fairly esoteric machine language, as this sort of code works right down there with the bits and monsters of the hardware of a PC.

While we have discussed the code in isolation, we have not seen how it works with real world software as yet. Because most applications programs which might use the serial port will be written in a higher level language, like C or Pascal, we must devise a way for such a program to communicate with our driver.

There are several approaches to this, each with its own advantages and disadvantages. We're going to look at one of them in detail this month.

To Drive or Not to Drive

Over the last few months, we've discussed how machine language functions can retrieve bytes from a circular buffer, bytes which have been placed there asynchronously by the interrupt handler for the serial port card. In devising a strategy to make these functions accessible to an application program, we must come up with a channel of communication between the assembly language code and an application.

There are four things which the machine language driver, whatever that turns out to ultimately be, should offer the application which calls it. These are as follows:

- **A setup routine to initialize the serial port, the interrupt handler and the baud rate.**
- **A character out routine to send data to the serial port.**
- **A character in routine to get data from the input buffer.**
- **A test routine to see if there is any data waiting at the serial port buffer.**

This could be expanded upon, and might well have to be for certain types of applications, but these four functions will handle basic telecommunications through the port.

The PC offers us a number ways to implement these. We'll deal with them here in order of decreasing complexity.

If DOS had its way, it would have you implement the serial port driver as a

"device driver". This is a special type of machine language program which DOS loads through the CONFIG.SYS file of your system. The ANSI.SYS file is a device driver which is commonly used.

When DOS boots up, it creates a number of "standard" devices, such as CON and PRN. These behave somewhat like files. If you do something like this:

```
COPY TEXTFILE.DOC PRN
```

the contents of the file TEXTFILE.DOC will be sent to your printer, that is, to the parallel port LPT1. The PRN device looks like a file to DOS, but all its contents go to the printer port. There is also a device called LPT1, by the way, which does much the same thing.

You can write a device driver which will create a new device name and make it accessible to other programs. For example, you could write one which would create a device called SERIAL, such that reading from and writing to SERIAL would handle interrupt driven communications with the serial port.

This is a flexible way to deal with the port, but it has some drawbacks. It means that anyone wishing to use a program which deals with the port this way must have your device driver installed in their CONFIG.SYS file. Device drivers remain in memory, tying some of it up, even when the functions they perform aren't needed. In addition, communication between a program and a device driver is not blindingly fast.

Finally, device drivers are pigs to write.

The next most sophisticated approach is to create a dedicated high speed serial software interrupt. In this case, you would write a memory resident program which would seize an otherwise unused software interrupt and dedicate it to driving your serial port. You would, in effect, be adding another INT service to the PC's BIOS. You could then create subfunctions for this interrupt.

This is a good way to handle some sorts of serial applications, especially those which will be moving a relatively small number of relatively large blocks of data. If you were to create your driver such that you could pass it a pointer and let it hand your application several kilobytes of accumulated data with each request, this approach would have a lot of merit.

It's not too good for character by character communications, however, which tends to be how most serial applications work. Executing an INT instruction takes a considerable amount of time in machine terms, with quite a bit more tied up in the requisite pushes and pops of the handler. This is somewhat at odds with the goal of creating a high speed serial device.

The simplest approach is the least flexible but the most functional. It involves simply writing the driver so it can be 'bolted on'' to your application. The driver only exists as part of your program, but it's tightly bound to it and suffers the least time penalty when your program goes to talk to it.

In this example I've assumed that the application program in question will be written in C. However, at the level that this driver works there's very little difference between languages. You'll find it just as applicable to Pascal or compiled BASIC with a minimum of fiddling.

When you compile a C language program the result will be a number of machine language functions which behave in a predictable way. You can't actually write a workable driver in C, because higher level languages rarely generate tight enough code to manage a serial port efficiently. However, you can create assembly language functions which look to C like C functions, except that they're work a lot faster.

A C function takes its arguments as integers pushed onto the stack and returns things in AX register. Under Turbo C, assembly language functions must preserve the SI and DI registers if the compiler is set to allow for the use of register variables. In addition, every assembly language function must take care to either preserve or at least not mangle the BP register, as this is what the function which called it was using to find its stack arguments prior to the call.

Having written a driver which will bolt onto a C language program, all we have to do to use it is to include it in the linking process... adding its name to the project file under Turbo C... and call the functions it provides as if they were included with the compiler.

This is the complete serial port driver written as a machine language module for a C program. I called this SERIO.ASM, so when I assembled it I got SERIO.OBJ.

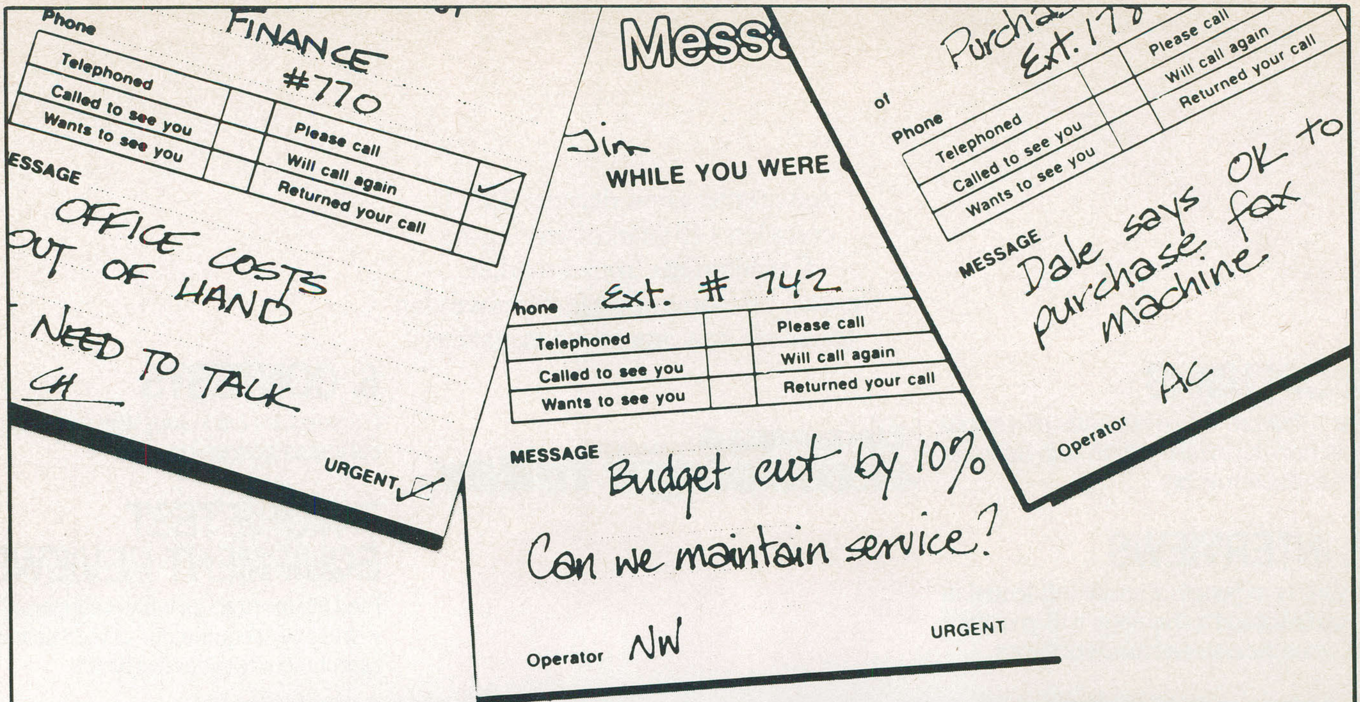
```
SERIO_SIZE EQU 512 ;THE BUFFER
SIZE
A_OFF   EQU 6 ;THE STACK OF-
FSET

;THIS MACRO SAVES ANY REGS
THAT MIGHT BE USED BY THE COM-
PILER
SAVE MACRO
PUSH SI
PUSH DI
ENDM

;THIS MACRO RESTORES ANY REGS
THAT MIGHT BE USED BY THE COM-
PILER
RESTORE MACRO
POP DI
POP SI
ENDM

SERIO_TEXT SEGMENT BYTE
PUBLIC 'CODE'
ASSUME
CS:SERIO_TEXT,DS:_DATA

;THIS ROUTINE CLEARS THE BUFF-
ER AND RESETS THE POINTER
;
;  CALLED AS
;  SerioReset();
;
PUBLIC _SerioReset

_SerioReset PROC FAR
SAVE
MOV AX,_DATA
MOV DS,AX

MOV AX,OFFSET SERIO_BUFFER
MOV SERIO_HEAD,AX
MOV SERIO_TAIL,AX
RESTORE
RET
_SerioReset ENDP

;THIS ROUTINE SENDS A CHARAC-
TER OUT TO THE SERIAL PORT
;
;  CALLED AS
;  SerioPutch(c);
;  intc;

PUBLIC _SerioPutch

_SerioPutch PROC FAR
PUSH BP
MOV BP,SP
SAVE

MOV BX,[BP+A_OFF]

MOV AX,_DATA
MOV DS,AX

MOV DX,SERIO_BASEPORT
ADD DX,5

SUB CX,CX
SP1: IN AL,DX   ;GET MODEM
STATUS
AND AL,20H   ;CHECK CTS AND DSR
CMP AL,20H
JE SP2
LOOP SP1
```

```
SP2: MOV DX,SERIO_BASEPORT
MOV AX,BX
OUT DX,AL
RESTORE
POP BP
RET
_SerioPutch ENDP

;THISROUTINERETURNSA
CHARACTERFROMTHEBUFFER
;
;  CALLEDAS
;  c=SerioGetch();
;  intc;/*ifc&0x0100,nocharacter*/
;
PUBLIC _SerioGetch

_SerioGetch PROC FAR
SAVE

MOV AX,_DATA
MOV DS,AX

MOV BX,SERIO_HEAD
CMP BX,SERIO_TAIL
JNE SG1
MOV AX,0100H
JMP SG2

SG1: SUB AX,AX
MOV AL,[BX]
CALL BUMP_POINTER
MOV SERIO_HEAD,BX

SG2: RESTORE
RET
_SerioGetch ENDP

;THISROUTINERETURNSTHENUM-
BEROFWAITINGBYTES
;
;  CALLEDAS
;  c=SerioTest();
;  intc;
;
PUBLIC _SerioTest
_SerioTest PROC FAR
SAVE

MOV AX,_DATA
MOV DS,AX

MOV AX,SERIO_HEAD
SUB AX,SERIO_TAIL
RESTORE
RET
_SerioTest ENDP

;THISROUTINERETURNSTRUEIF
CLEARTOSEND
;
;  CALLEDAS
;  c=SerioReady();
;  intc;
;
PUBLIC _SerioReady
_SerioReady PROC FAR
SAVE

MOV AX,_DATA
MOV DS,AX

MOV DX,SERIO_BASEPORT
ADD DX,4
IN AL,DX
AND AL,01H

RESTORE
RET
_SerioReady ENDP

;THISROUTINESETSTHEBAUD
RATE
;
;  CALLEDAS
;  SerioBaud(p);
;  intp;/*baudratedivisor*/
;
PUBLIC _SerioBaud
_SerioBaud PROC FAR
PUSH BP
MOV BP,SP
SAVE
MOV BX,[BP+A_OFF]

MOV AX,_DATA
MOV DS,AX

MOV SERIO_BAUD,BX

RESTORE
POP BP
RET
_SerioBaud ENDP

;THISROUTINEINSTALLSTHE
SERIALVECTOR,
;
;  CALLEDAS
;  SerioOn(p);
;  intp;/*comport1or2*/
;
PUBLIC _SerioOn
_SerioOn PROC FAR
PUSH BP
MOV BP,SP
SAVE
MOV BX,[BP+A_OFF]  ;COMPORT
TOUSE

MOV AX,_DATA
MOV DS,AX

MOV AX,0
CMP SERIO_SEG,0  ;DON'TIN-
STALLTWICE
JE SM1
JMP SM3

SM1: CMP BX,2
JNE SM2

MOV SERIO_BASEPORT,02F8H
MOV SERIO_VECTOR,0BH
MOV SERIO_MASK,0F7H

SM2: CLI
MOV AH,35H
MOV AL,SERIO_VECTOR
INT 21H
MOV SERIO_SEG,ES
MOV SERIO_OFF,BX

MOV AL,SERIO_VECTOR
PUSH DS
MOV DX,OFFSETSERIO_HANDLER
PUSH CS
POP DS
MOV AH,25H  ;CHANGETHE
SERIALINTERUPTVECTOR
INT 21H
POP DS

IN AL,21H
AND AL,SERIO_MASK
OUT 21H,AL

MOV DX,SERIO_BASEPORT
ADD DX,3
MOV AL,80H
OUT DX,AL  ;OPENDLAB

MOV AX,SERIO_BAUD ;GETTHE
BAUDRATEDIVISOR

MOV DX,SERIO_BASEPORT
ADD DX,1
MOV AL,AH
OUT DX,AL  ;SENDHIGHORDER

MOV AX,SERIO_BAUD ;GETTHE
BAUDRATEDIVISOR
MOV DX,SERIO_BASEPORT
OUT DX,AL  ;SENDLOWORDER

MOV DX,SERIO_BASEPORT
ADD DX,3
MOV AL,7   ;ANDTHECFWBYTE
OUT DX,AL  ;ALSOCLOSEDLAB

MOV DX,SERIO_BASEPORT
ADD DX,1
MOV AL,01H
OUT DX,AL  ;INTERUPTENABLE

MOV DX,SERIO_BASEPORT
ADD DX,4
MOV AL,08H
OUT DX,AL  ;MODEMCONTROL

MOV AX,1   ;SAYITWORKED

SM3: STI
RESTORE
POP BP
RET
_SerioOn  ENDP

;THISROUTINEUNDOESTHEVEC-
TOR
;
;  CALLEDAS
;  SerioOff()
;
PUBLIC _SerioOff
_SerioOff PROC FAR
```

```
MOV AX,_DATA
MOV DS,AX

CMP SERIO_SEG,0000H
JE SO1

CLI
IN AL,21H
MOV AH,SERIO_MASK
NOT AH
OR AL,AH
OUT 21H,AL

MOV DX,SERIO_BASEPORT
ADD DX,3
IN AL,DX
AND AL,7FH
OUT DX,AL

MOV DX,SERIO_BASEPORT
ADD DX,1
MOV AL,0
OUT DX,AL

MOV DX,SERIO_BASEPORT
ADD DX,4
MOV AL,0
OUT DX,AL

MOV AL,SERIO_VECTOR
PUSH DS
MOV DX,SERIO_OFF
MOV DS,SERIO_SEG
MOV AH,25H ;CHANGEINTERUPT
VECTOR
INT 21H
POP DS

MOV SERIO_OFF,0000H
MOV SERIO_SEG,0000H

SO1: STI
RET
_SerioOff ENDP

;THISROUTINEHANDLESTHE
SERIALINTERUPTFORTHESERIO
SERIO_HANDLER PROC FAR
STI ;ENABLEOTHERINTERUPTS
PUSH AX
PUSH BX
PUSH CX
PUSH DX
PUSH SI
PUSH DI
PUSH DS
PUSH ES

MOV AX,_DATA
MOV DS,AX

MOV DX,SERIO_BASEPORT
IN AL,DX

MOV BX,SERIO_TAIL
MOV SI,BX

CALL BUMP_POINTER
MOV SERIO_TAIL,BX
MOV [SI],AL
CLI
MOV AL,20H ;SIGNALENDOFIN-
TERUPT
OUT 20H,AL
STI

POP ES
POP DS
POP DI
POP SI
POP DX
POP CX
POP BX
POP AX
IRET ;RETURNTOCALLING
CODE
SERIO_HANDLER ENDP

BUMP_POINTER PROC NEAR
PUSH AX
MOV AX,OFFSETSERIO_BUFF-
ER+SERIO_SIZE
INC BX

CMP BX,AX
JGE BUMP_PTR1
POP AX
RET

BUMP_PTR1:
MOV BX,OFFSETSERIO_BUFFER
POP AX
RET
BUMP_POINTER ENDP
SERIO_TEXT ENDS

DGROUP GROUP _DATA,_BSS
_DATA SEGMENTWORDPUBLIC
'DATA'

SERIO_BASEPORT DW 03F8H
SERIO_VECTOR DB 0CH
SERIO_MASK DB 0EFH
SERIO_OFF DW 0000H
SERIO_SEG DW 0000H
SERIO_BAUD DW 0060H
SERIO_TAIL DW OFFSET
SERIO_BUFFER
SERIO_HEAD DW OFFSET
SERIO_BUFFER
SERIO_BUFFER DB SERIO_SIZE
DUP(?)
_DATA ENDS

_BSS SEGMENTWORDPUBLIC
'BSS'

_BSS ENDS
END
```

The driver is a bit complex when you first come upon it, but it turns out to be pretty easy to deal with from the point of view of a C program.

We'll discuss the workings of the driver, and how to interface to it, in the next installment of this series ■



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